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The Big Gas Engine Question.

There was recently printed in this journal an account of the starting and successful test of the first of a large group of 3,000-h.-p. gas-driven blowing engines for the Carnegie Steel Co. Of course a 3,000-h.-p. gas engine is no novelty, and the successful use of blast furnace gases is old, yet the work here noted is significant as showing the beginning of their use on a very large scale in an industry in which continuous operation is imperative. Blast furnace gas is of somewhat dubious and irregular quality, yet as a normal by-product of the steel furnaces it is a large and important source of energy. To utilize it effectively the gas engine must have special design and must be both rugged mechanically and able to work well with a rather uncertain quality of fuel. The qualifications which fit a machine for good work in this instance are such as should make it extraordinarily reliable in cases where uniform fuel is available. It is the successful solution of unusual difficulties that makes the Carnegie Steel Works installation notable. The great thermodynamic virtues of the gas engine are now well understood. With producer gas it is capable of delivering power regularly on one pound or less of coal per brake-horse-power-hour and of operating steadily for long periods of time. It has the steam engine in all its forms beaten to a standstill in point of thermal efficiency, and it seems under ordinary conditions fully as reliable. Why, then, its relatively slow introduction?

This question is a somewhat complicated one. In the first place the gas engine has been much neglected by American engineers in all above the most trivial capacities. Like the steam turbine is was developed abroad and seems to have been regarded with a certain Chauvinism as a blanked theoretical foreign machine—theoretical being the last word of condemnation when no legitimate objection remains. For years, with respect to both machines the Westinghouse Co. was a sort of voice crying in the American wilderness. Its prophetic instinct has now been justied. The diversion created by the introduction of the steam turbine has been indeed one of the things which has hindered the introduction of the large gas engine. Engineers have been a little shy of gas units in view of the vivid, if somewhat over-colored promises made for steam turbines. In efficiency and economy of first cost these latter have not yet made good in spite of their undoubtedly valuable properties, and the gas engine is not yet driven from the field. But it suffers from an economic difficulty in that it must be sold, albeit a rather expensive machine to build, at a figure that puts it in competition with steam on installation cost. Were it in large production, as it one day will be, the costs could be brought down enough to make its manufacture profitable. But at present it must be sold on rather close margin for competitive reasons, and hence it is a less attractive machine to boom than some others. American manufacturers can build as well and cheaply as anybody when once things are in full production, but prior to that point they are apt to go slowly and cautiously.

It is the extensive use of gas engines in such special work as this of the steel industry that is likely to put the building of big gas engines fairly upon a commercial basis and to lead the way to their more general use for other purposes. There must be, of course, a great deal of experimentation on various forms before manufacture settles down to a steady basis. This much can be said, that the double-acting, four-cycle engine, such as is used in the Carnegie Steel Co., has been proved over and over again to be both efficient and reliable. Whether the two-cycle engine on which many experiments are now being tried can be made equally so seems open to doubt. If it can be the cost of plant should be materially reduced. Yet even with a four-cycle type the cost is not serious when economy of operation is taken into account. We are slow in this country at increasing investments to cheapen operation, and yet we are learning the lesson. In the last resort economy of operation must win out. We are to-day in an age of exploitation, yet there are signs that here and there a company is beginning to look ahead and to regard its enterprise as a stable one to be put upon a sound, permanent basis. Even some of the so-called trusts have begun to take a more far-seeing outlook than has been attributed to them. The nearer we come to the idea of great and stable industrial investments the more closely is it necessary to keep down ultimate expense. One cannot safely predict the advances which will be made in prime movers in the next few years, yet it is safe to say that the gas engine has too great qualifications in economy to be pushed aside unless by improvements in steam practice of which there is now no sign. It has already made good its title to a unique economic position.

Industrial Organization and the Personal Equation.

One of the inevitable tendencies of industrial progress on a large scale is the submission of the will of the individual worker to the controlling regulations necessary to maintain an efficient organization. There is no other way in which the combined efforts of thousands of men can be directed through the proper channels. Metes and bounds must be set around the activities of the railway contractor's gang no less definitely than they must be established for the crack corps of a military campaign; and the large drafting room must be organized as effectively and with as much positive responsibility of rank as the factory. On all important engineering jobs the proper organization of the working forces is the first concern of executive officials.

The imperative claims of organization are questioned by no one who aims at large results, but in many branches of industry there is to-day a feeling among subordinate employes that personality cuts very little figure in the face of vast combinations or working units and methods, and a feeling, even among department heads, that the system is more important than the man behind it. A recent writer upon the subject of getting new power business for central stations illustrated this point of view when he stated that the solicitor should not attempt to remember the details of any but the immediate deal in prospect, but that the card index should be the absolute key to the situation. Young engineers are prone to think that the simple tasks of checking up requisitions and pay rolls or measuring station platforms with a hundred-foot tape are of practically no importance in the routine of the great organization which employs them, and the busy executive at the head of the sales department is often inclined to assign territory for temporary trips with greater regard to the sequence of arrivals from previous jobs than to the personal equation of the employe with respect to the peculiar conditions of the field.

It will not do to lose sight of the fact that in all work above the lowest grade of routine machine tending, personality must be reckoned with if the organization is to be permanently successful. The division of labor has been carried so far that there are many tasks in the factory which appear to require but little intelligence for their execution, but even here a knowledge of the structure of the complicated machine and the ability to make simple adjustments is of much value to the company operating the equipment. Creative work of any kind involves the personal equation at the outset, and the young engineer who slights any of his duties in the mistaken belief that even he is a mere unit in the success of his organization fails to seize the opportunity which every such task brings as a stepping stone to something better. All this sounds a good deal like moralizing, but the fact is that correct arithmetic is needed in the modern industrial world quite as much if not more than the integral calculus.

Excessive organization can only be made properly effective and simplified by individual initiative, and only the directed energy of personality can meet changing conditions promptly and efficiently. In the engineering industries the dangers of adhering too closely to mere systems are ever present, for it is a peculiar fact that the operation of most engineering appliances in commercial service demands workers whose wages are modest, to say the least. Ignorance of duties lying outside a very narrow sphere flourishes in over-organized concerns; responsibility is hard to fix and error difficult to correct. Maximum efficiency demands intelligent, far-sighted efforts to secure the best results on the part of the individual employe, and appreciation of the limitations of system and value of personal initiative on the part of the industrial executive.

Buying Equipment on Rush Orders.

Quick deliveries are such prominent features of so many modern equipment contracts that the actual excess cost of rush order production is rarely realized by the busy railway or industrial manager in these piping times of prosperity. The enlargement of operating organization tends to concentrate executive power; questions of policy become constantly more important as public interest in great industries grows, and the problem of foreseeing the needs of the future is often passed by in the stress of giving daily decisions upon points of instant importance. It is easy for matters to drift along until a sudden awakening comes in the shape of broken-down equipment and repair shops filled to overflowing. Then follows the acceptance by telephone of the bid promising quickest delivery, and the expenditure of much time, railroad mileage and nervous energy of the high-priced kind to force the manufacturer to meet as nearly as possible the contract date of shipment.

There are plenty of cases in engineering practice where the necessary equipment simply cannot be anticipated a long time before it is wanted. In the field of railroad construction a supposedly ample supply of steel rails and bridge timber may be ordered for a proposed extension, but a decision of the executive committee of the board of directors involving a sudden change of route is handed into the engineering department offices some morning, and there follows an increase of 10 or 15 per cent. in the amount of material which must be ordered, and on a rush basis. The engineer in charge cannot be blamed for not ordering more than the estimates show to be necessary for the route of least cost, for to have done so would have been to run the risk of tying up large sums needlessly. Broad questions of policy, depending upon the political situation, public sentiment, and other factors may have made it impossible for the directors to foresee their action. Again, the unexpected passage of a stringent city ordinance requiring all the wires of an electric light and power company in certain congested districts to be laid underground by a certain early date may carry with it the necessity of extra quick deliveries in the conduit construction supply field. It is a difficult problem to anticipate the requirements of the future when uncertain factors of public policy or unforeseen increases in business enter the normal situation.

Rush orders are often justified, but one cannot escape their extra cost when it comes to settling the bill. It may pay the man whose time is precious—not merely valuable—to travel from Chicago to New York on one of the excess fare limiteds, but surely there ought to be a quick counting of the cost and probable advantages of so doing before the office boy is sent for the tickets. A fire may destroy a quarter of a million dollars' worth of cars some wintry night in a street railway car house, but the gain in earning capacity secured by a delivery of two months on rush orders against double or triple the time at a lower price may be so great that the forced production plan is the cheaper in the end. But whatever may be the decision, the fundamental point remains that rush order work costs heavily. Labor must be paid higher wages for overtime service; if Sunday work is necessary, its cost is relatively excessive, and even if extra pay be advanced for night work, it is doubtful if the lasting quality of production is as good as work done by daylight.

When the manufacturer has a reasonable time in which to turn out an equipment job, a better opportunity is afforded for proper inspection, and the material entering the product can be selected more carefully. The advantage of the market can be taken in such cases, sometimes, in buying supplies. The more careful work results in lower maintenance charges in service and in longer life. The rush order bid must be large enough to cover contingencies which do not enter the regular production of standard equipment, and there must be a charge exacted for the more or less serious interference with regular output. Nowhere is there a better illustration of the adage that "time is money" than in the cost of rush order production. It is a wise and far-sighted manager who has his operating proposition in such close hand that he can order equipment far enough ahead of the game to pay a handsome interest on its cost under rush order conditions.

The Gatun Locks.

There has lately been some evidence of official uncertainty concerning certain matters connected with the proposed Gatun locks for the 85-ft. summit level lock plan for the Panama Canal. These locks, it will be remembered, have, in the wisdom of the President, been changed from the rather restricted dimensions of the minority plan to the dimensions recommended by the majority of the Board of Consulting Engineers, viz., 1,000 ft. usable length and 100 ft. usable width. At the behest of the President the Commission made this change of lock plan against its inclination. It is therefore imperative that there should be no shadow of doubt thrown upon the stability of the foundations of these great masonry structures on which depend not only the safety but the possibility of operation of the lock canal if it is ever completed. While the Commission has been distinctly cautious about giving to the public much information in regard to these important foundation questions, the Senate Committee on Interoceanic Canals appears to be determined to secure the most complete information about this and other canal plan questions. This is fortunate for engineers, for it is obvious that some very interesting foundation questions are arising in connection with both the locks and the earth dam at Gatun.

In a letter recently received by the Commission from the Chief Engineer on the Isthmus, and published in the daily press, he states that any impugnment of the solidity of the Gatun locks is "either the product of diseased imagination or wilful lies." This is strong language and indicates at least a rather sanguine temperament on the part of the author, for it is now known that some short core fragments of the so-called soft rock or indurated clay taken from a boring at the Gatun lock site and sent to Washington for the information of the Commission and the Senate Committee almost instantly went to pieces when immersed in water. In other words this specimen of "soft rock," so-called, was immediately turned to mud when immersed in water. Such material certainly does not promise to be either a suitable or a durable foundation for a great lock structure. There might be some apprehension as to what would take place after completion of the lock if water should find its way into such mushy material as that disclosed by this boring. It must be remembered that this disintegrable clay or other material is now high and dry in its natural position but would be submerged by the proposed Gatun Lake. It seems scarcely credible that such conditions can be seriously considered as suitable for the stability of these unprecedented masses of lock masonry which, if built at all, ought to be founded upon firm bed rock, as to the durability or solidity of which no question whatever could possibly arise.

This feature is by no means the whole story revealed by the latest diamond drill and other borings made at a considerable number of points at these lock sites. There have been made during the past season numerous borings at the location where it is proposed to construct the Gatun locks. Here, the public has been assured from time to time, the lock foundations are to be constructed in the indurated sandy clay or "soft rock" extending underneath the geological gorges containing the silt filling on which it is proposed to build the earth dam, but the records of these borings show that this supposed indefinitely extended bed mass of soft rock under the lock site is mainly or possibly entirely a great nest of lumps of that material, some comparatively small and others large. Out of a total of ten sections shown on one blue print record the majority of holes penetrated sand or clay or other soft material after piercing lumps of so-called soft rock varying in thickness from about 10 ft. to 30 ft. The supposed foundation masses of these rocks therefore might almost be termed lumps floating in sand, clay or other soft material, and at such short distances below the original surface in many places as to leave but a few feet between the bottom of the lock and the soft material underlying the hard lumps. In one or two cases the bottom of the lock would rest directly on the clay and sand. These are facts disclosed by the latest information given to the Senate Committee, and how much more there may be of a similar character or worse, and thus far not disclosed, is, of course, a matter of conjecture. This observation is justified when it is remembered that the freely water-bearing character of the material on which it is proposed to build the earth dam was not mentioned in the minority report on which the present lock plan is based. This condition of soft material underlying what has too often been taken for bed rock on the Isthmus and in Central America is not surprising to those who have had experience in this line of investigations. It is constantly encountered in those countries in consequence of the volcanic origin of the present geological conditions, in which strata are literally mixed in the most topsy-turvy fashion with no rational order of position. In spite of these facts, as late as the middle of this month the Commission and the Senate Committee have been assured by the Chief Engineer that "nothing in any investigation which has been made during the last year and a half has tended to show but that the foundations of the Gatun locks will be as solid as the eternal hills. . . ." The President does not usually show much lack of faith in his capacity to settle questions of any character whatever within the entire range of human experience, but there are some signs on his part of a little faltering, or at any rate of some desire for inquiry, in connection with these features of the proposed lock plan. In fact not only a full inquiry as to these things is now imperative, but the time has come when fudging clearly dangerous results into shape to bolster up a thoroughly inadequate plan of canal should be abandoned in favor of natural and sound engineering procedures leading to the design and construction of a safe, sensible and stable ship waterway across the Isthmus.

The Proposed Mississippi Bridge at St. Louis.

The announcement in this journal last week that Messrs. Henry Rohwer and Carl Gayler had been retained to report on the best site for a new bridge across the Mississippi River at St. Louis, indicates that it is not at all unlikely the next long-span structure to be put under contract in this country will be located there. Nobody who has visited St. Louis often needs to be told that such a structure is much needed, for the present facilities for getting into the city from the East are not only overtaxed, but are hopelessly antiquated in many respects, particularly in the matter of innumerable grade crossings with streets. The freight business at St. Louis and East St. Louis has more than doubled in the last ten years, and its further increase is apparently limited only by the facilities afforded, for the two cities form a great receiving and forwarding center, the importance of which is little recognized outside of railway centers. For transportation purposes the city may be said to include a district within a radius of twenty miles of the court house and including the territory on both sides of the river. The development of railway facilities in this district has now reached a condition which demands that whatever is done shall be planned for the future as well as the present. The extent and nature of the railway business there are such that the city must make unusual concessions to the railways, and at the same time must grant these franchises and privileges so that they shall work toward benefiting a comprehensive plan rather than individual roads. The problem is a complex one because so many roads are concerned, because it is necessary to furnish better facilities for receiving and delivering freight, and because it is imperative to furnish additional means of interchanging freight between the two sides of the river.

The subject has been recognized as vitally important for some time, and two years or so ago a commission was organized to make a careful study of the situation. This commission retained Messrs. Robert Moore and Albert T. Perkins to investigate the conditions and suggest remedies, and their report made about six months ago is an engineering document of exceptional interest. It shows that while there is no difficulty in providing ample space for yards and shops, the problems connected with the development of freight houses and team tracks and their connection with the yards is a complicated one. Any consideration of these improvements is also so closely tied up with the construction of an additional bridge that the two form one subject, and the fact that both the public and the railway interests recognize the necessity of a remedy for the existing congested and inadequate conditions warrants the belief that another bridge will be built before long.

The Eads bridge was built in the face of opposition sufficiently powerful to prevent its location further downstream, where it would be more satisfactory as a railway connection. The East St. Louis approach is very inconvenient for trains from the South, while on the west approach there is a 4,000-ft. tunnel which is not only highly objectionable to passengers, but is so located that the train movements through it are slow and easily deranged. The structure is so unsatisfactory from a railway point of view that for many years important through trains have been sent, when possible, over the Merchants' Bridge, although the approach to the latter for a distance of two miles is an excellent example of grade crossings run riot. Only a part of the trains on a part of the roads can be sent by this route, so that it is wholly inadequate as a solution of the difficulties. The only complete remedy, as Messrs. Moore and Perkins have shown by detailed proof, is the construction of a new bridge, which will require no tunnel and will be equally accessible to all roads from the East.

It has been fully shown that such a bridge can be built, but it should be for railway service wholly. The location suggested for it last year was one giving no usefulness whatever to vehicles. On the basis of a 1,600-ft. clear span and a capacity of four tracks, it was estimated to cost about $8,000,000, including right of way, approaches and track with signals. It would have a train capacity about eight times that of the Eads bridge, owing to its superior location and the absence of any tunnel. It is a great undertaking, but some such structure must be built before long. The Eads bridge is an anachronism as a railway bridge, but it will remain an admirable highway connection between the leading streets of the two cities which it joins. Eventually it must come under municipal control if not municipal ownership, for the development of inter-city electric traction will make it imperative to introduce radical improvements in the street car service. The present complications due to the private ownership of the bridge and the various leases under which cars are run over it will eventually be untangled. The city's action in promoting the construction of a bridge which will withdraw most or all railway business from the Eads bridge will doubtless materially assist the solution of the problem.

Notes and Comments.

The Esprit de Corps of a great technical organization of any sort is one of the most interesting demonstrations of its efficiency. Whenever several hundred well-educated men are brought together on some work, there is bound to be occasional jealousy and some friction, but there is a tremendous difference between the degree in which such feeling characterizes different organizations. There are some engineering corps where every man's hand is raised against his associates, above, below, and on the same level with him. Any frank statement by one of these men regarding his work throbs with suppressed wrath and bitterness. The men are well paid, but the organization is inefficient because nobody is really willing to do anything that will not help his own personal advancement. There is a diametrically opposite kind of an engineering organization, where everybody is working for a single object and a feeling of comradeship exists that helps smooth out many hard tasks. This feeling does not depend on large salaries, for it is often found in organizations where the rates of compensation are only moderate; but it depends in a very large degree on the choice of men for the organization and the personal interest in them which their chief shows. Consequently the man who picks out his staff with a view to team work is the man who is likely to get results, particularly if he can keep his people assured of his personal interest in each of them. These thoughts are suggested by the dinner given a short time ago by Mr. J. Waldo Smith, chief engineer of the Board of Water Supply of New York, to all the employes in his bureau, men and women, department chiefs and day laborers. It is no secret that he considers his staff the finest ever brought together for a civil engineering undertaking, and this journal is able to bear witness of its own knowledge to the admirable esprit de corps which extends through all its ranks. Mr. Smith has been working to develop this spirit from the time his bureau was started. His force is stationed along a line probably 150 miles long, and in order to get the men together he has encouraged various social organizations and has planned methods of keeping the men on one part of the work informed concerning what is going on elsewhere along the line, so that all may feel themselves a part of an organization with a single purpose. The dinner at New York was merely one of many acts which show not only how important this unity of action and feeling is regarded by Mr. Smith, but also how finely the entire staff is responding to his skilful direction, and the hearty appreciation it has for a policy which regards men as something more than machines. While it was a most unusual thing for a chief engineer to invite every member of a force to a celebration at headquarters at his personal expense, it should also be pointed out that a good many of the five hundred people who gathered about the dinner tables came at much inconvenience to themselves in order to show their regard for their chief and their associates. It is probably the first occasion when such a meeting was held in New York, and those outsiders who were permitted to be present went away with the firm conviction that, in spite of all criticisms to the contrary, it is possible to bring together in municipal service an engineering organization of large size which will be animated by the single idea of willing obedience to its head.

The Pollution of Rivers is discussed in the annual report of the State Health Commissioner of New York, who is making an investigation of the extent of such contamination at the present time. He is of the opinion that the continued pollution of rivers and lakes must stop and will give no permit to discharge crude sewage into such waters except for very cogent reasons. He strongly urges the grant of authority to him to compel the cessation of pollution of this nature where it is necessary to the public health to have it stopped. There can be no question about the value of such an examination as is now being made to ascertain the contamination of water nor about the desirability of preventing any pollution which is dangerous to public health. This journal has grave doubts, however, regarding the desirability of putting any such comprehensive powers in the hands of a health officer as seem to be requested by Commissioner Porter. The problem of sewage disposal is beset with too many difficulties and uncertainties to be further complicated by arbitrary action on the part of public officials whose duties are already arduous. Nothing could do greater harm to progress in sanitation than the arbitrary action of a public official requiring the treatment of sewage before its discharge into a stream able to dispose of it satisfactorily by dilution. A still greater chance of trouble lies in the probability that a public officer would be inclined to require a greater degree of purification of the sewage before its discharge into a stream than is really necessary. The experience in such matters of control in England has not been such as to arouse any very urgent desire to repeat the experience here. There are not many sanitary engineers in the United States whose experience, knowledge and temperament fit them to decide disputed questions of sewage disposal in a manner that is equitable and at the same time safe from the standpoint of the public health. Before any legislation is passed giving great powers to a health commissioner, it would be well to ascertain from the men who are most responsible for recent progress in sanitary engineering just what legislation can be granted that will be efficient and at the same time not prevent progress. Any wholesale requirement to stop the discharge of crude sewage into rivers and lakes is wholly unnecessary, and any legislation which permits a health officer to dictate the degree of purification which sewage must receive before its discharge into a stream, irrespective of the character and uses of that stream, will eventually lead to trouble.

The Traveler for the Erection of the Quebec Bridge.

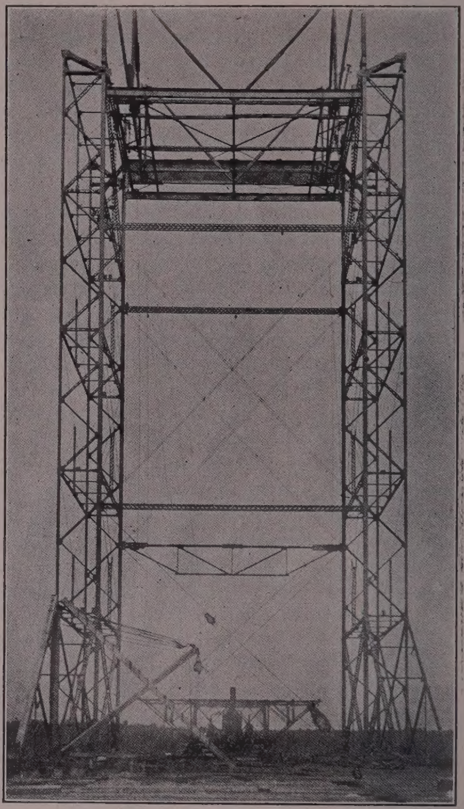
The traveler for the erection of the Quebec bridge is much the largest ever built and was briefly described in The Engineering Record of March 4, 1905. It is of the same type as those described in these columns for the erection of th Wabash R. R. bridge at Pittsburg, and the Mingo bridge across the Ohio River, but unlike them or any other large traveler previously used for cantilever erections it is of the gantry type and is built to run outside the trusses with sufficient vertical and horizontal clearance to pass uninterruptedly back and forth over the completed structure and thus permit the lateral and sway bracing to be permanently connected as fast as the trusses are assembled. This adds greatly to the stability of the incomplete span and proportionately reduces the risk from wind and storm during erection. These features, together with the great depth of the trusses, 315 ft. on centers, and the enormous size of the members to be handled, some pieces being about 100 ft. long and weighing more than 100 tons, make unprecedented dimensions necessary for the traveler and involve provision for very large stresses and unbalanced reactions. The design has been developed with great care, and the calculations have been made and the shop work has been executed and inspected with the same accuracy as for a permanent railroad structure, the result being that during two seasons' service, the traveler has given complete satisfaction, has erected about 17,000 tons of the finished structure, has withstood severe storms, maintained its maximum calculated loads and is in excellent condition to complete the remainder of the work.

The traveler is made entirely of steel and has a Z-shaped side elevation, consisting of a 54x103-ft. steel tower 212 ft. high, with a 66-ft. cantilever extension in front at the top, which commands one full panel of the incompleted structure in advance of the traveler and affords supports for the tackles by which the members are hoisted. At the rear end, a corresponding projection at the base supports the hoisting engines and serves to partially counter-balance the eccentric loading on the forward arm. The structural steel in the traveler weighs about 2,000,000 lb., and its total weight with hoisting engines, tackle and other equipment is about 2,225,000 lb.

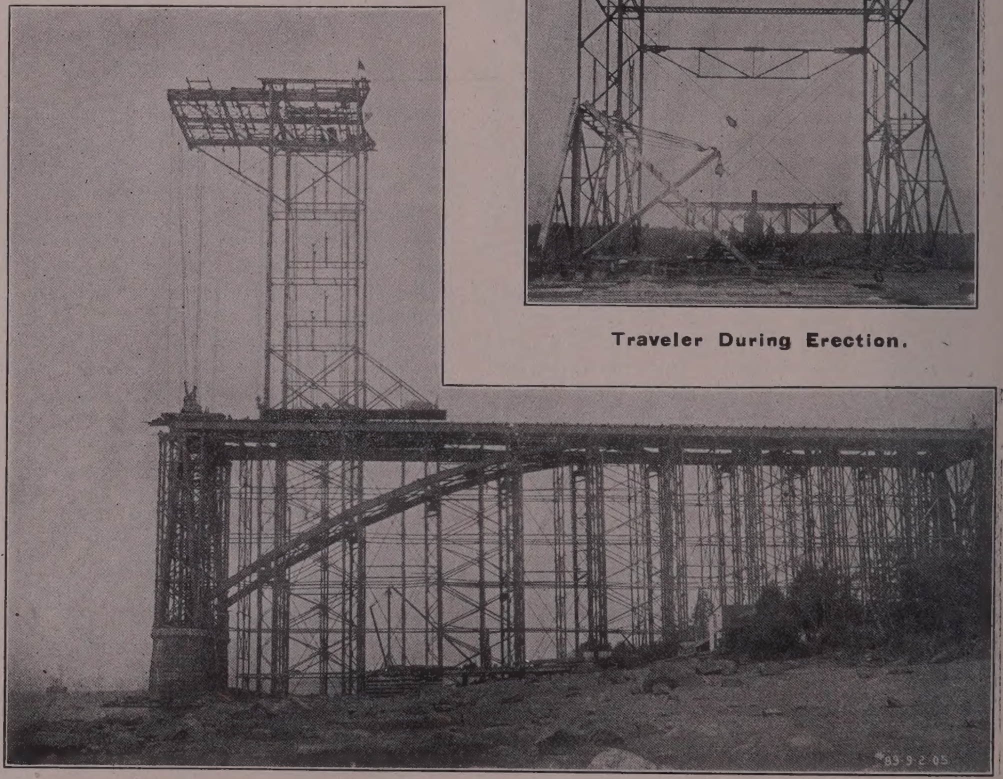
For the erection of the anchor arm, it was supported by the steel falsework on which the great trusses were assembled. For the erection of the cantilever arm, it is supported on longitudinal girders carried outside the permanent trusses by temporary vertical posts and transverse girders suspended from the bottom-chord panel points of the finished structure. On the river side of the main pier only 225 lin. ft. of traveler track are provided. They are made in sections successively removed from the rear and erected in front of the traveler. This effects a considerable saving in erection material, although it makes it impossible for the traveler to retreat a great distance from any point attained on the cantilever arm. This restriction is not, however, objectionable, since the erection is entirely completed for a given panel before the traveler advances beyond it, and when it reaches the extremity of the cantilever arm, its functions for that portion of the bridge will be completed and it will be taken apart, taken across the river and reassembled for the erection of the other half of the structure.

The traveler tower is made of two transverse bents, each having two pairs of vertical posts connected only by latticing between the posts of each pair and by deep transverse girders at the top over the highest point of the permanent trusses. The two bents are connected by horizontal struts and by diagonal rods, and the cantilever arms and the horizontal lateral bracing on top are arranged as indicated in the general plans and elevations. The lower trusses are integral with the bottom part of the tower and their lower chords serve as sills for the base of the tower. They also support floors of 3-in. plank which cantilever 8 ft. beyond the outside trusses and thus form on each side of the traveler a 20x108-ft. platform on which the hoisting engines are located and which is used for general storage and erection purposes. With the exception of the diagonal rods in the tower bracing, which have pin-connected clevice ends, all of the traveler members have connections made with jaw plates and turned bolts instead of field rivets to facilitate reassembling. The top chords of the upper cantilever trusses are likewise continuous across the tops of the tower and are connected transversely at all panel points by plate girders which support several lines of longitudinal jigger beams.

The permanent structure and the method of erection have been designed to reduce as much as possible the number of members supported at any one time by the traveler during the erection of any given panel of the bridge. Most of the pieces are handled in pairs, the corresponding members of each truss being erected simultaneously. Some of the riveted members weigh 105 tons each, and the groups of eyebars which are handled together in complete sets for each panel weigh as much as 100 tons, including their clamps and hoisting attachments. Consequently very considerable loads are imposed on the overhang of the traveler and it is calculated that it may be subjected to a total load of as much as 500,000 lb. from several members that are being wholly or partly supported or hoisted from it simultaneously. The two outside vertical posts and the two outside top and bottom cantilever trusses, together with their bracing, virtually form a single Z-shaped truss in a longitudinal plane, and the two corresponding inside posts and trusses form similar longitudinal trusses which, on each side of the bridge axis, are braced together by horizontal trusses and diagonal ties as indicated by the general drawing.



Traveler During Erection.



South Anchor Arm after Complete Erection of Lower Chord.

Each vertical post was shop-riveted and shipped in five sections, field-spliced with web and flange cover plates. The forward inside posts serve practically as fulcrums for the cantilever arms and have maximum stresses. They have rectangular cross-sections made of a pair of 15-in., 43-lb. channels with their flanges turned in and latticed on one side and connected by a 20x⅜-in. cover plate on the opposite side, and have pairs of jaw plates riveted to their webs and flanges to receive the connections for the tower bracing.

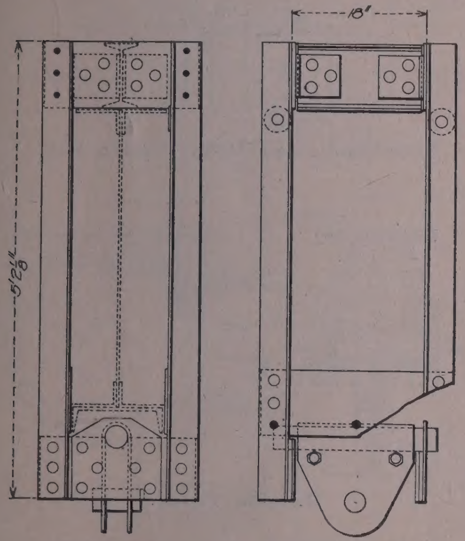
At the foot of the post, the channel webs are connected by diaphragms, and solid plate brackets are extended each side to provide web-connections for the sills and girders. The posts continue beyond the lower-flange bearings of these connections and have horizontal base plates designed to transmit the stresses directly to the track stringers when the traveler is in service. The outside posts have corresponding construction, but are lighter, being made of pairs of 8-in. channels. The horizontal longitudinal struts connecting the vertical posts are made of pairs of channels having their flanges turned in and latticed. The diagonal rods in these panels of bracing are pairs of 1-in. rods, each made in two sections clevis-connected at the center to four pins in a pair of jaw plates riveted to the upper end of the short vertical strut similar to the horizontal strut and supporting the latter at the center.

The inside and outside vertical posts in the same transverse bents are connected by zigzag pairs of angles, latticed together and bolted to jaw plates on the faces of the posts. The top and bottom cantilever trusses are made entirely of riveted members composed of pairs of channels with their flanges turned in and latticed. The corresponding inside and outside trusses are connected by horizontal struts with X-bracing of diagonal rods in the panels between them. The top chords of the upper cantilever trusses are each made in three pieces, and the overhanging portions are connected by single zigzag angles bolted to tie plates across their flanges.

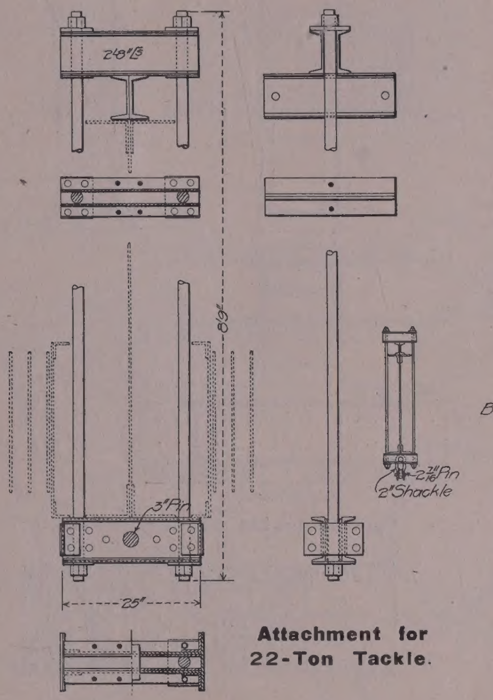
The chord of the inside truss is made very deep to serve as a jigger beam for supporting hoisting tackles. Each web is virtually an independent plate girder 40 in. deep with two 6x6x5/8-in. flange angles on the outside. There are reinforced holes 3 13/16 in. and 5 13/16 in. in diameter to receive the axles of sheaves or the connections for hoisting tackles. The plate girders connecting the inside top chords are 8 ft. deep, and to them are web-connected three lines of longitudinal plate girder stringers or jigger beams, provided with attachments for hoisting tackles and thoroughly braced by a complete system of horizontal diagonal angles transferring all lateral stress to the tops of the vertical posts.

The bottom chords of the lower inside trusses are made of a pair of built channels 22 in. deep, having their 3x3-in. flange angles turned inwards and latticed. The webs are connected by vertical transverse diaphragms and are field-bolted at the end to the wide gusset plates, shop-riveted to the planed vertical post of the tower, which form both splices and connection plates at these points. The bottom chords of the outside lower trusses are similar to those of the inside truss, except that the flange angles are turned outwards and at the front end they are made continuous across the feet of the vertical posts and are provided with vertical angles forming pockets and bearing seats for the nuts on the anchorage bars.

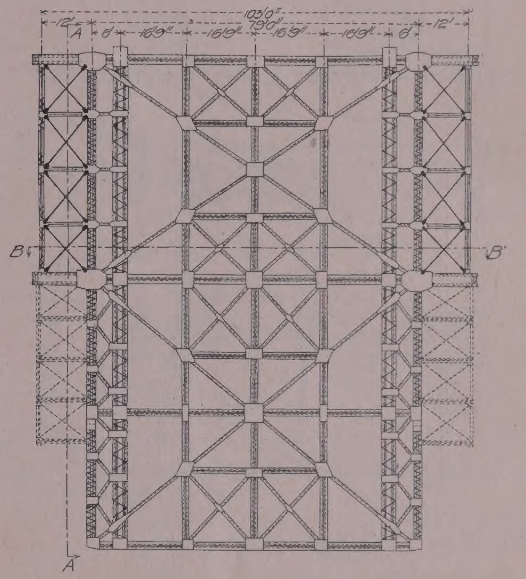
The traveler is mounted on 24 double-flange cast steel wheels 26 in. in diameter. The wheels are connected to single and double trucks, and the trucks are connected to the foot of each vertical post with adjustable horizontal bearings un-

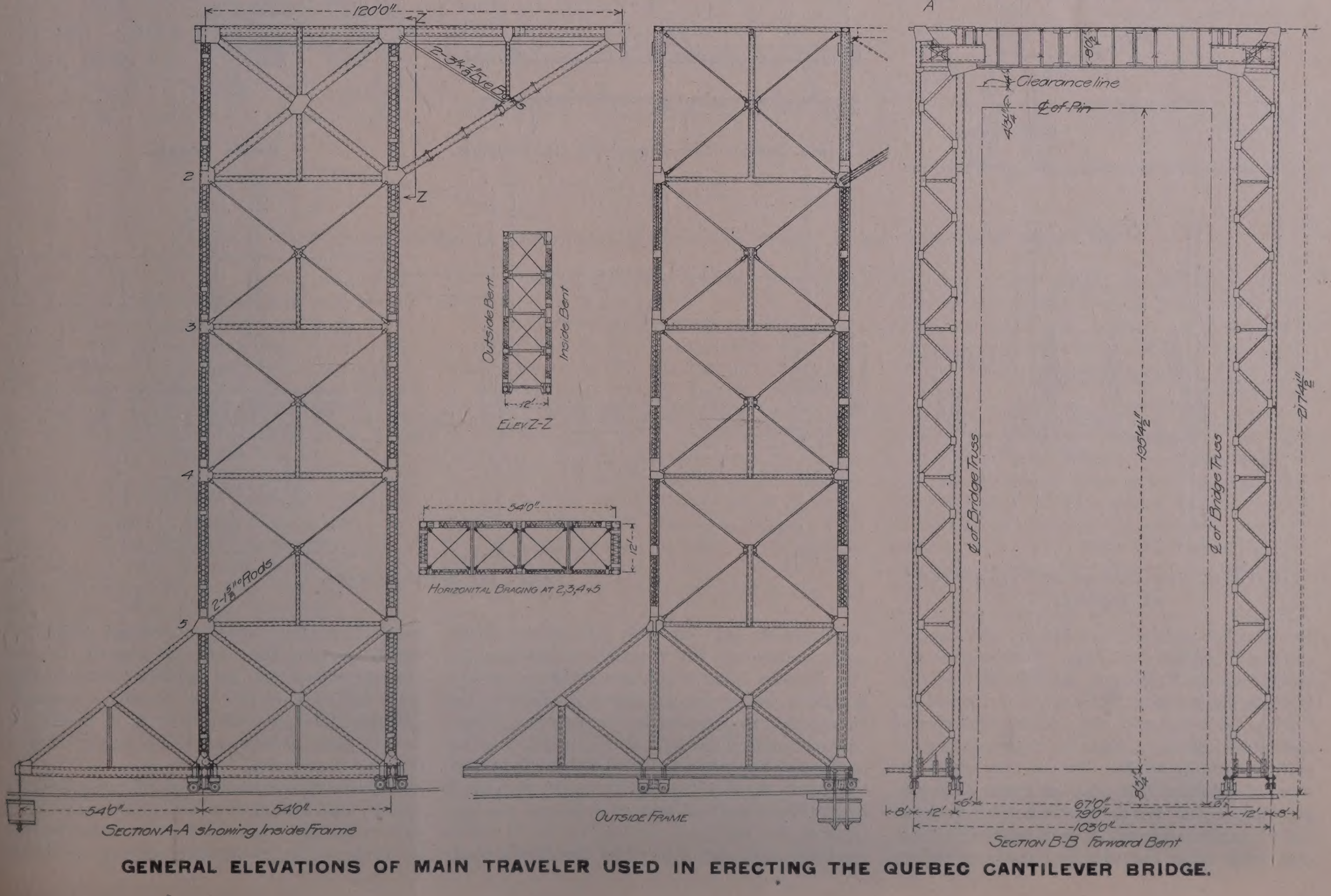


Attachment to Center Stringer for 18-Ton Tackle.



Attachment for 22-Ton Tackle.





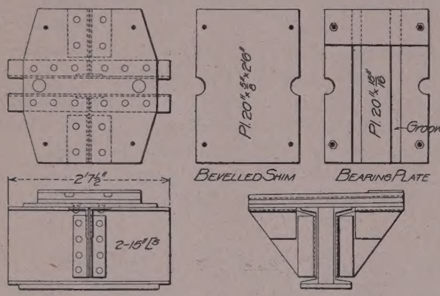
GENERAL ELEVATIONS OF MAIN TRAVELER USED IN ERECTING THE QUEBEC CANTILEVER BRIDGE.

der the flange plates at the feet of the posts, just clear of the bottom chords of the cantilever trusses. The trucks on the outside trusses have single wheels, those on the inside trusses have double wheels 30 in. apart transversely on centers.

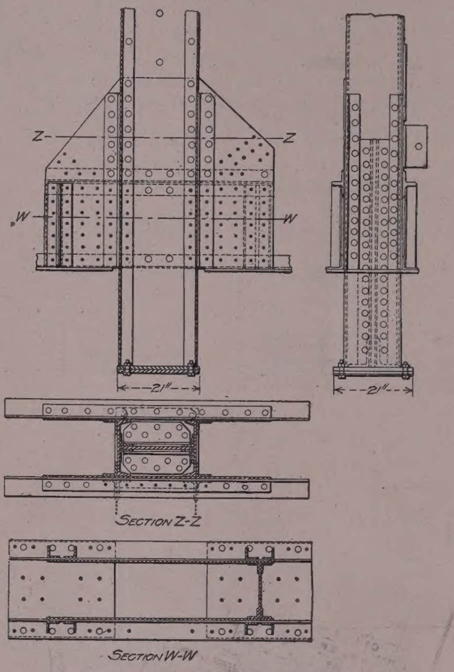
The trucks are of very simple construction, resembling a shoe for the pin-bearing at the end of a bridge truss. Those for the double wheels have their vertical web plates reinforced to give two bearings 6⅝ in. long, bushed with Ajax metal ⅝ in. thick, with diagonal oil grooves. The axles are turned to a diameter of 6¾ in., and are provided with pressure oil cups. Turned steel collars ½ in. thick separate the wheels from the faces of the bearings. The upper surface of the truck is made of a 1-in. plate, countersunk-riveted and fitted with bolts engaging the wings on the vertical posts or passing through shim plates interposed between them and the truck. The single wheel trucks for the inside posts have axles 5¾ in. in diameter and 16½ in. long, with bearings made of heavy cast-steel boxes bolted to single vertical web plates. Shims provided for the trucks vary in thickness from ⅛ to ⅞ in. and are used to adjust the positions of the trucks to correspond with the grade of 1 per cent. and maintain the traveler post vertical in all positions.

In order to put the traveler in service, groups of 8x10-in. wooden ties 18 ft. long under the three traveler-track rails on each side of the bridge axis are removed and their places are filled by sets of 10-in. I-beams arranged on the centers of the posts and under the wheels to support the front posts, as indicated in the elevation. Castings and shim plates are then arranged between the tops of the beams and the bottoms of the vertical posts to give bearing for pairs of folding steel wedges, inserted between them and the bottoms of the post and overlapping 15 in. under the inside post and 7 in. under the outside post. Each wedge is driven 6 in. and raises the traveler ⅛ in. Two hydraulic jacks are then operated under the inside forward posts to raise them until their wheels are entirely relieved of dead load. The shim is then inserted and wedged up tightly, and the rear anchorages of the traveler are screwed as tight as possible. The hydraulic jacks are then released, the forward anchorages are tightened and wooden blocking is placed under the lower chords of the cantilever truss near the rear anchorages.

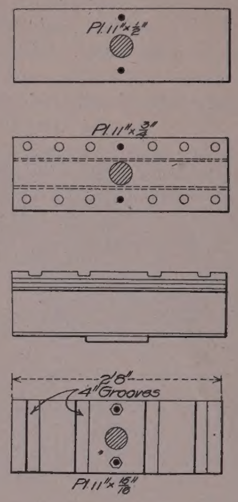
The rear anchorages are two 2⅜-in. square rods 13½ ft. long with upset screws at both ends. The nuts on the upper ends of these rods take bearing on flange plates at the extremity of the lower



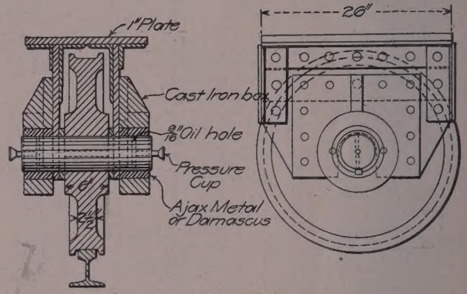
Forward Anchorage Under Outside Post.



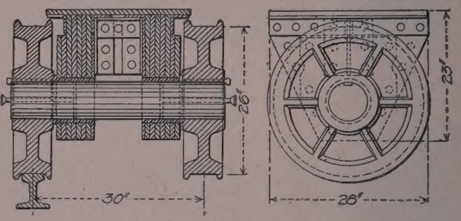
Foot of Inside Forward Post.



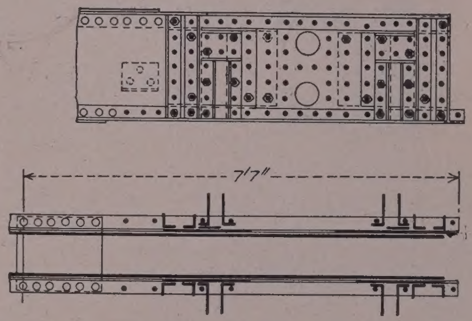
Rear Anchorage Under Inside Post.



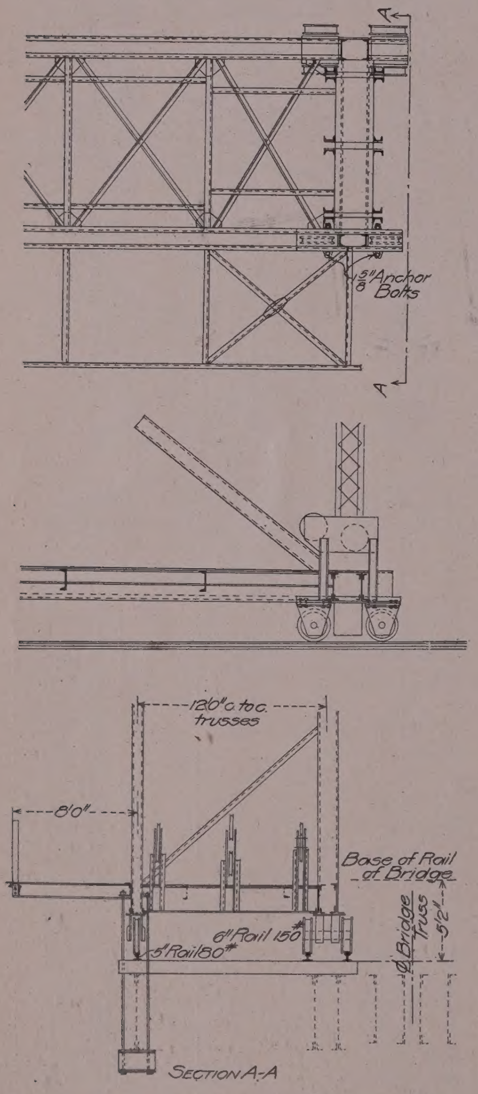
Outside Truck.



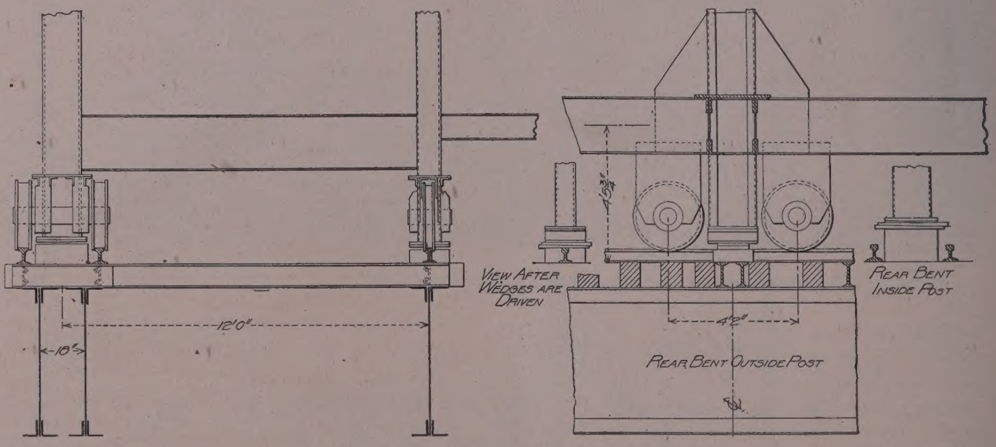
Inside Truck.



Outside Cottom Chord at Post Connection.



Trucks at One Corner of Forward End of Traveler.



Truck for Outside Post.

chords of the inside truss and those at the lower end engage reaction beams across the lower flanges of a pair of track stringers. Each reaction beam consists of a pair of 7-in. channels 32 in. long and 4 in. apart back to back. To the upper flanges of the channels are riveted a cover plate and an outside plate, the latter having transverse grooves across it to clear the rivet heads in the stringer flanges. Across the lower flanges there is riveted a plate to take bearing on the nut of the anchor rod. The grooved top plate is tapered 1/8 in. in the full length to correspond with the grade in the track.

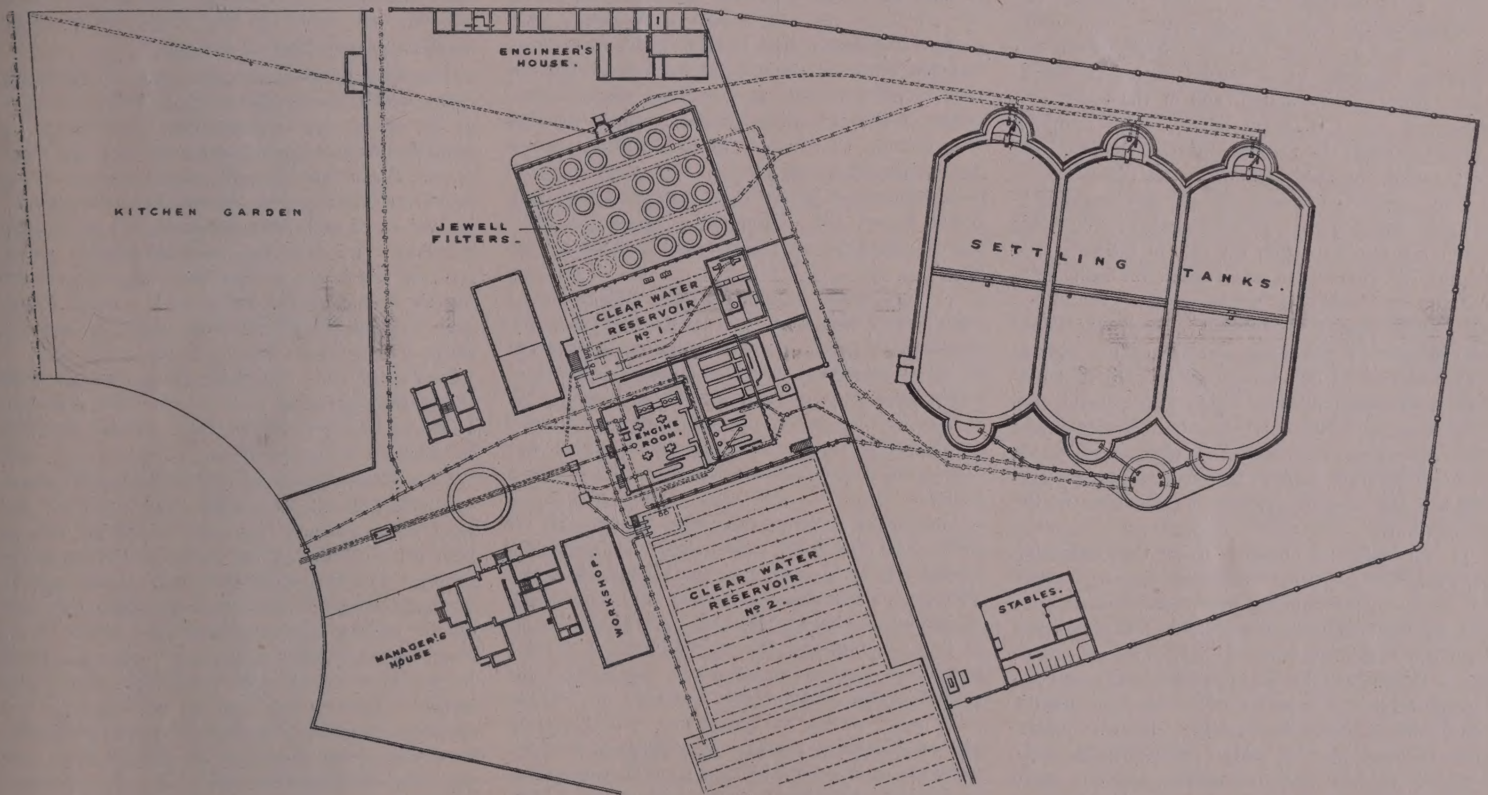
The anchorage at the forward end of the traveler consists of eight 1 5/8-in. square vertical rods 13 1/2 ft. long with upset screw ends. The top nuts pass through pocket angles riveted to the webs of the lower chords of the outside trusses, and their nuts take bearing on the ends of the angles. There are four bars at the foot of each outside vertical post. They are arranged in pairs, one on each side of the track stringer, and their lower ends pass through a transverse reaction beam engaging the bottom flange of the stringer. This beam is made of a pair of 15-in. channels 31 1/2 in. long and 3 in. apart back to back. Cover plates are riveted to the top and bottom flanges and are bored to receive the anchor rods, which have nut bearings on the lower plate. The upper cover plate is 30 in. wide, projecting on each side of the reaction beam, and is stiffened with transverse diaphragms which extend the bearing and distribute the pressure over 2 1/2 lin. ft. of the stringer. A top plate, tapered to correspond with the grade and having longitudinal grooves planed in it to clear the stringer flange rivets, is bolted to the cover plate.

Mr. E. A. Hoare is the chief engineer, and Mr. Theodore Cooper the consulting engineer of the bridge. The contractor for the steel work and the superstructure is The Phoenix Bridge Co., Mr. John Sterling Deans, chief engineer, and Mr. A. B. Milliken, superintendent of erection.

THE EIFFEL TOWER at Paris is now used as a wireless station by the French Government. Communication has been maintained with ease with the eastern frontier of France.

The American System of Filtration at Alexandria, Egypt.

There was printed in this journal on Feb. 10, 1906, a detailed description with illustrations of the purification plant built at Mansourah, Egypt, by the Jewell Export Filter Co. This was not the first plant of the type furnished by the company for Egyptian use, however, for it had operated an experimental plant at Alexandria some years before with such success that the municipal authorities and the Alexandria Water Co. gave up their plans for large slow-sand filtration works and contracted with the Jewell representative, Mr. E. A. Gieseler, for rapid filtration works. These were constructed, before the Mansourah plant was finished, under the direction of Mr. H. R. C. Blagden, who prepared a detailed description of them that has recently been published by the Institution of Civil Engineers. The following notes with the accompanying illustrations are taken from that paper.



General Plan of the Pumping Station and Purification Works of the Alexandria Water Co.

The water is drawn from the so-called Mahmoudieh Canal on the outskirts of the city. The canal is fed by the Nile about 45 miles away, and is used by boats passing between Alexandria, Cairo and the intermediate villages. When it is realized that this canal is the receptacle for all the refuse and other impurities from the navigation, and also to a large extent for the drainage of nearly all the villages situated along its banks, it will be readily understood how necessary it is for the health of the inhabitants of Alexandria that every care should be taken with the treatment of the water before delivering it into the town.

The company has to supply filtered water for a population (according to the last census, taken in 1901) of nearly 400,000 people, including natives, and the daily consumption of water ranges, according to the time of year, between 4 1/2 and 8 million imperial gallons, the maximum consumption being at the time of year when the condition of the water in the Nile is at its worst, and consequently throws a maximum amount of work on the filters. The company supplies more than 15,000 private services, which are rapidly increasing, and in addition it provides water for the poorer native population at fountains which are distributed all over the native quarters, the water being sold in skins containing about 16 imp. gal., which are carried on men's backs and distributed from house to house.

The company has its intake from the Mahmoudieh Canal at a point about 3/4 mile from the main pumping station, and has a small pumping station at the intake for raising the water from the Mahmoudieh into its private canal. The canal runs direct to the main pumping station into three collecting wells immediately in front of the main engine house, from which the low-service pumps take their suction. The water is raised from these wells by the low-service pumps and delivered through a 30-in. main to the settling-tanks, where it has a rest of at least 6 hours under the influence of a solution of sulphate of alumina which is injected into the 30-in. main half way between the pumping station and the settling tanks; after leaving the settling tanks the water passes through a 36-in. main to the filter house and finally into the clear water reservoirs, whence it is pumped by the high-service pumps into the service reservoir, against a head of 87 to 90 ft.

Settling Tanks.—The settling tanks, three in number, are designed to hold 985,000 imp. gal. each. There is a circular distributing basin at one end, containing about 55,000 imp. gal., into which the whole of the unfiltered water is pumped by the various low-service pumps from the canal; this distributing basin is in direct communication with each of the three settling tanks, being connected by three 24-in. pipes and sluices to enable any tank to be shut off when required. Each settling tank is provided at the inlet end with a semi-circular basin, 22x11 ft., having the same depth as the settling tanks and communicating with them at the bottom. Each settling tank is also divided half way up its length by two masonry walls, each 2 ft. in thickness, one wall acting as a baffle wall, and the other—that nearer the inlet—as a weir; the latter has no openings in it except a wash-out valve which is always kept shut when the settling tanks are working. The baffle wall is provided with eight openings at the bottom, through which the water passes from the first compartment into the second, after having passed over the middle weir already referred to. The second compartment is of exactly the same capacity as the first, and is provided at the outlet end with a masonry outlet weir the whole width of the tank, over which the top film of the settled water passes into a semi-circular outlet basin, 22x11 ft., whence it passes through a 30-in. sluice valve into a 36-in. main leading to the filters. In addition to this outlet weir there are also provided two cast-iron adjustable weirs, each 9 ft. in width, of special design, and working in gun metal guides; these weirs, under normal conditions, are kept at the same level as the masonry weirs, and can be lowered 12 in., if necessary, in the event of the water becoming low in the settling tanks, due to a sudden draw-off by turning on additional filters, or until the engine attendant has time to increase the speed of the low-service pumps so as to bring the water in the settling tanks to its normal level. Under ordinary circumstances the level of the water never varies more than 3 in., every inch of variation being accurately recorded by a special electrical instrument indicating on a dial, and at the same ti [illegible] recording on a diagram in the main pumping station, so that the rate of filtration and the rate of pumping the unfiltered water are identical.

The variation between the day and night supply for the town is compensated by the clear water reservoirs, so that the rate of filtration and number of filters used can remain the same during the 24 hours. In preparing the ground for the foundations of the settling tanks it was found that practically the whole surface of the ground was undermined and honeycombed with old disused wells and culverts, which had probably belonged to the former town of Alexandria and had served for its water supply; considerable money, therefore, had to be expended in solidifying the soil so as to ensure a solid bed for the foundations.

It was plainly obvious from the beginning that the only way to arrive at this was to arrange for an extensive flooding of the whole area after the excavations were completed; consequently a temporary 16-in. pipe was laid as far as the middle of the excavations and pumping was continued intermittently for a period of 50 days and nights, representing, according to the engine counter, about 250,000 tons of water. Considerable subsidences at once became evident, and for more than 30 days such subsidences had to be filled up from time to time until no further signs of settlement were evident, and the water stood about 2 ft. in depth over the whole area. After the soil had become more or less dry on the surface, the whole area was rolled over with a 16-ton steam-roller which gave a far greater pressure per square foot than the soil would ever be subjected to by the weight of the masonry and the water in the tanks. The whole surface, therefore, was thoroughly well pressed before any concrete was put in.

The walls and bottoms of the settling-tanks were made much thicker and considerably heavier than was necessary to resist the mere water-pressure, in view of the very uncertain condition of the sub-soil. Hydraulic cement-concrete was used throughout, mixed in the following proportions: Lime and pozzolana (Santorin), mixed ¾ pozzolana and 1 lime, 2 parts; sharp sand, washed and screened, 6 parts; Portland cement, 1 part. The substance of the concrete consists entirely of ancient broken pottery (Chakf), which is found locally in immense quantities, and is particularly well suited for concrete-work on account of its practically flat sides and sharp angular edges, which afford an excellent bond. In spite of the comparatively low rate of labor in Egypt, a considerable amount of machinery was employed in connection with the concrete-making. The Pozzolana and lime were ground together in edge-runners and afterwards screened, the refuse of the screen being returned to the edge-runners, so as to ensure a perfect mixture of the two materials. The broken pottery was screened by [illegible] large rotatory screens arranged with two rings of ¾-in. mesh to remove any dust, and two rings of 2½-in. screen consisting of perforated steel plate through which the Chakf passed; all refuse from these screens was broken in a Blake stone-breaker to the required size. The Chakf was measured out on mixing-tables, about 13 x 7 ft., double-boarded to prevent leakage, and the mortar, having been previously mixed wet in a pug-mill, was added in a wet state; the whole was then thoroughly mixed by hand-labor before being used on the work. A complete system of light railways was installed for the transport of the material, in order to expedite the work as much as possible.

With the exception of the bottom of the basins the whole of the concrete-work, including side-walls, end-basins and weirs, was formed in wooden centering; this centering constituted one of the most difficult parts of the work, on account of the somewhat peculiar shapes required. The amount of concrete in the settling-tanks is approximately 13,000 cu. yd. The concrete-work was commenced on April 18, 1904, and was completed by the end of September, giving an average of about 78 cu. yd. per day, including Sundays.

The inside of the settling-tanks was rendered with cement-plaster, in two layers, having a total thickness of ¾ in., the first rendering being about ½ in. in thickness and composed of 3 parts of sharp sand to 1 part of Portland cement; the surface of this layer was left rough to form a good keying for the finishing layer, which was composed of 1 part of sand to 1 part of Portland cement.

The whole surface of the bottom of the tanks was then lined with a layer of bituminous asphalt, ⅜ in. in thickness, applied hot, thus rendering it absolutely water-tight and impervious to leakage. The asphalt was covered with 2 in. of fine concrete and cement-rendering to form a protection against damage when cleaning out the settling-tanks. The inside surfaces of all the walls were treated on completion with the well-known Sylvester process, consisting of the application of a solution of soap and water, followed by a solution of alum and water, which, when applied in two or three coats, has the effect of entirely closing the pores of the cement-rendering, and consequently prevents any moisture creeping through the masonry; this is especially desirable when the retaining-walls stand out of ground and are exposed to view, as on these works.

Filters.—The filters, eighteen in number, are of the Jewell Export Filter Co.'s gravity-type, Figs. 3 and 4, Plate 1. Each filter is 17 ft. in diameter, giving 226 sq. ft. of filtering surface, and consists of a substantial riveted steel tank, 7 ft. in height, containing the filtering-sand, about 3 ft. in depth, supported in the ordinary way by a layer of fine gravel.

The filtered water leaves the filter through small screens, and thence passes through an automatic regulating Weston controller. The condition of the filtering-surface is recorded automatically by means of a loss-of-head gauge, which indicates when the filter requires washing by arriving at the point corresponding to the greatest possible pressure under which the filter will give its full quantity of water.

The filters are erected on circular cement-concrete foundations, built up from the bottom of the clear-water reservoir and projecting through the covering of the reservoir, so as to give the filters the desired elevation; they are arranged in two batteries, viz., one battery of ten filters and one of eight filters, with six spare foundations, so that six additional filters can easily be added when necessary, thus making a total of twenty-four filters, arranged in two batteries of twelve filters each. The filters are contained in a handsome brick building 138 x 103 ft., constructed of Italian bricks.

Wash-Water Tank.—In connection with the washing arrangements for the filters there is provided a circular steel tank, 34 ft. in diameter by 10 ft. in depth, mounted on a strongly braced steel structure and containing 50,000 imp. gal. of filtered water at an elevation varying between 30 ft. and 40 ft. above the tops of the filters. This tank is erected at some little distance from the filters, and is connected by a 12-in. pipe to the wash water-pipes inside the filter house. Water for filling this tank is supplied by the 10-in. centrifugal pumps in an auxiliary engine-house; the tank is covered in at the top, and has a covered gangway all round, so that it is well protected from the strong rays of the sun.

The filter house is provided with an operating floor, which stands about 12 in. below the tops of the filters, and is accessible from both main entrances by handsome ornamental cast-iron staircases. From this floor all the work of operating the filters is performed; the spindles of the operating valves of each filter are continued up through the floor, and are each provided with a valve-post, on which are fixed a brass name-plate bearing the name of the valve, and a brass index-gear to indicate whether the valve is open or shut.

An automatic reservoir gauge is provided above the operating floor so that the attendant knows at any moment the exact amount of water in the clear-water reservoir.

Clear-Water Reservoir.—The clear-water reservoir under the filters is subdivided into three distinct compartments, any one of which can be shut off and cleaned out without disturbing the others. The bottom of this reservoir is made in hydraulic cement-concrete of the same materials as the settling tanks. The whole of the clear-water reservoir, both inside and outside the filter-house, is covered with expanded metal and cement-concrete, supported on steel girders and cast-iron columns, a sufficient number of inspection traps being provided for getting down into the reservoir. On that part of the covered reservoir which is outside the filter house the concrete is covered with a layer of asphalt, ¾ in. in thickness, which renders the covering impervious to water and prevents leakage of dirty water into the reservoir.

Two additional covered clear-water reservoirs are provided on the other side of the main pumping station; these were originally slow sand-filter beds, but have been entirely reconstructed, the side walls having been underpinned all the way round and new concrete bottoms put in. These reservoirs are also covered over with expanded metal and cement-concrete. The three clear-water reservoirs together contain 1,760,000 imp. gal. of filtered water, which is about one-quarter day's supply for the town.

Auxiliary Machinery.—Immediately outside the filter-house, and on the top of the clear-water reservoir, is an engine-house, 52 x 27 ft., by 37 ft. in height, containing the auxiliary machinery in connection with the filter plant, and on the upper floor the alum mixing apparatus and chemical laboratory.

The pumping engine plant on the ground floor consists of two sets of Belliss & Morcom high-speed engines, each of 70 i.h.p., with their own surface-condensing plants standing in the basement and driven by belt. The engines are arranged with extended bedplates and two outer bearings carrying continuations of the crankshafts on which are mounted two pulleys, one for driving a 10-in. Sulzer centrifugal pump, and the other for driving a countershaft which drives a dynamo for lighting purposes; this countershaft also drives, by means of belting, the whole of the shafting in the filter house, in connection with the revolving agitators on the filters. The Sulzer pumps, which are used for the filter washing, are of the high-lift type, capable of delivering 1,000 imp. gal. of water per minute against a head of 60 ft.; they take their suction from the clear-water reservoir immediately underneath them, and deliver the water up to the wash-water tank, which supplies the filtered water under pressure for washing the filters, as already described. In the corner of this engine-house there is a large alum store capable of holding about 80 tons of sulphate of alumina. In connection with the wash-water tank there is a Kent electrical recording instrument fixed on the wall, which records every inch of rise and fall of the water in the tank.

The coagulant feed is of the same type as that illustrated in connection with the Mansourah filters, and has a capacity sufficient for twenty-four filters; it is so arranged that any number of filters from one to twenty-four can be properly supplied with the desired quantity of coagulant.

Main Pumping Station.—The original pumping station, which was built about the year 1860, remains very much the same so far as the building is concerned, although it now contains practically none of the original machinery. The present pumping plant consists of two compound condensing beam engines, with high-pressure cylinders 18½ in. in diameter by 3 ft. 8 in. stroke, and low-pressure cylinders 30 in. in diameter by 5 ft. 6 in. stroke; each engine is arranged with a high-service filtered-water pump on one side of the beam and a low-service unfiltered-water pump on the other side. Each high-service pump is capable of delivering 3,300,000 imp. gal. per 24 hours against a head of 90 ft., and the low-service pumps, which were originally 10 per cent. larger than the high-service pumps for the old system of filtration, have now been replaced by smaller pumps, on account of the additional height to which the ulfiltered water has to be raised to reach the settling tanks. The low-service pumps take their suction directly from the canal and deliver it into the settling tanks against a gross head of 52 ft. The high-service pumps take their suction from the clear-water reservoirs and deliver it through a 20-in. and 24-in. main to the service reservoir against a gross head of 90 ft. There are also installed two compound beam engines working on one crank-shaft, the high-pressure cylinders of each engine being 18½ in. in diameter by 3 ft. 1½ in. stroke, and the low-pressure cylinders 29 in. in diameter by 4 ft. 6 in. stroke; they work one high-service double-acting plunger pump, 25 in. in diameter by 3 ft. 10 in. stroke, and one low-service pump of similar construction, 26½ in. in diameter by 3 ft. 10 in. stroke, directly from the beam. These engines, now somewhat out of date and merely used as a standby, have been at work about 25 years.

No new machinery was added until two and a half years ago, when it was found necessary on account of increasing demand to install some more powerful and more economical engines; accordingly, two triple-expansion pumping engines were added, one for high-service and one for low-service; each set is capable of delivering 6,000,000 imp. gal. in 24 hours. The engines are of the vertical marine type, condensing, the high-service engine having cylinders 14, 22 and 33 in. in diameter, by 36 in. stroke, and the low-service engine having cylinders 12, 18¾ and 30 in. in diameter by 36 in. stroke; in other respects the two engines and pumps are exactly similar. The pumps are of the three-throw, single-acting, plunger type, having plungers 22⅝ in. in diameter by 36 in. stroke. The high-pressure cylinders are fitted with Corliss valve gear having a special knock-out attachment in connection with a powerful governor, which is set to pull off a trigger and put the trip gear out of action when the engines are running three revolutions per minute more than their intended speed. The Corliss gear is also fitted with a brass index plate and a small hand wheel by means of which the expansion can be varied, so that the speed can be regulated to a nicety by the driver by varying the cut-off in the high-pressure cylinder. The intermediate and low-pressure cylinders are fitted with slide valve and expansion valves; the valves are not of the usual design, but are divided up so that each end of the cylinder has its own valves, and thus a considerable amount of clearance is economized; the expansion valves are fitted with Meyer gear, which admits of the rate of expansion being adjusted while the engines are running.

In connection with these two engines there is a separate surface condensing plant common to both engines; the condenser is of cylindrical form and of ordinary construction, having a cooling surface of 675 sq. ft.

There are also in the same engine-room two low-service engines and pumps, each capable of delivering 3,700,000 imp. gal. per 24 hours, of unfiltered water from the canal to the settling tanks, against a head of 52 ft. These pumps are two-throw, double-acting, plunger pumps, 15 in. in diameter by 20 in. strke, and are driven directly off the cross-heads of two vertical compound marine type condensing engines, having cylinders 10 and 20 in. in diameter by 20 in. stroke, and a working steam pressure of 160 lb. per square inch. The cranks are set at right angles and on each crank-shaft there is a heavy fly-wheel weighing 3½ tons, the cranks being balanced by metal in the rim of the flywheel. The high-pressure cylinders are fitted with Corliss valve gear and automatic knock-out gear similar to that on the triple-expansion engines already described; the low-pressure cylinders are fitted with a single slide valve worked by an adjustable eccentric, so that the cut-off may be varied as required. Each engine has its own surface condenser cast in the A-frames.

The boilers, four in number, are situated in the boiler-house adjoining the main engine-room. They are of the ordinary Lancashire type, 7 ft. in diameter by 25 ft. in length, each having two flues 2 ft. 9 in. in diameter. At the back of each boiler, and on the top of the back flue, is fitted a Schmidt flue-fired superheater, which superheats the steam up to 550° F. or nearly 190° F. above the temperature of saturated steam at a pressure of 160 lb. per square inch, which is the working pressure in the boilers. The gases, after leaving the superheaters, pass along a back flue, 6 ft. 6 in. by 2 ft. 9 in., to a Green economizer, having eighty tubes, and thence to the main chimney. Two Weir feed pumps are installed in the boiler-house, but are only used in cases of emergency, as all the main engines are fitted with their own feed pumps. At the back of the boiler-house a large coal store is provided, having a capacity of about 1,000 tons, and the coal is brought into the stoke-hole on a small light railway, the trucks passing over a small weigh bridge so that each load is weighed on its way into the stoke-hole. The coal employed is the best Welsh steam coal that can be obtained, the furnaces and fire-bars being specially designed for this fuel.

Efficiency.—The results leave no room for doubt as to the efficiency of the method of sedimentation and filtration; the action of the alumina in the settling tanks is most marked, and it has been found when cleaning out the settling tanks that the amount of deposit remaining in the first compartment of the settling tanks was nearly five times that in the second compartment, showing that the time allowed for sedimentation, which at present is 7 to 9 hours, is amply sufficient. The percentage removal of bacteria from the raw water is distinctly high, and exceeds the guarantee of the Jewell Filter Co.; the daily averages are very uniform, and never since the first month of the filter's working has the removal of bacteria been less than 98 per cent.

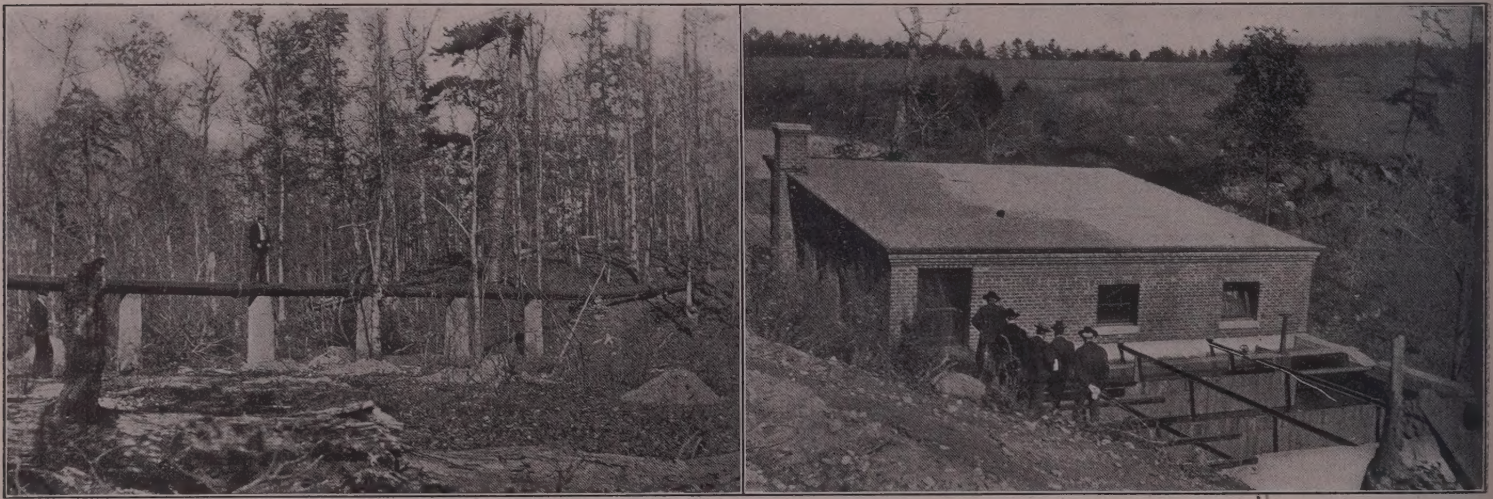
Cost of the Works.—The estimated cost of this filter installation, including two new boilers, two sets of low-service pumps, alterations to existing machinery and buildings, new buildings, settling tanks, pipe-work and valves, auxiliary machinery, filters and accessories complete, two covered clear-water reservoirs, etc., was £78,300, and in spite of several unforeseen contingencies this sum has not been exceeded in carrying out the work.

The preliminary drawings and arrangement, all estimates and specifications, and the detail drawings for the whole of the works, with the exception of the actual filters and th alumina feed apparatus, were prepared by Mr. Blagden, who also had entire charge of the execution of the work, which was carried out without a contractor. The designs for the Jewell filters and accessories were prepared by Mr. E. B. Weston, the consulting engineer to the Jewell Export Filter Co., whilst the filters were erected and put in operation under the direction of Mr. R. W. Lawton, superintendent of construction to the same company.

THE HONIGMANN METHOD OF SHAFT SINKING, though but little known outside the German coal fields, is said to be a very efficient method, and quite recently, in western Germany, seven shafts, varying between 12 ft. and 18 ft. in diameter, have been successfully sunk by it without noteworthy accident, through sands up to 600 ft. thick. The Honigmann method of sinking differs from others in requiring no casing until the shaft has passed completely through the sand to the solid rock. The means used to prevent caving in are, to raise the water level in the shaft to a certain height above the natural water level in the quicksand outside, and to increase the specific gravity of the water column in the shaft to about 1.2 by mixing clay with the water. According to Mr. A. E. Hartmann, from whose article in the "Engineering and Mining Journal" these notes have been taken, a pressure is obtained in this way which forces the clay held in suspension in the water into the shaft walls, thereby giving more stability to that portion of the quicksand and holding the inward pressure of the latter in equilibrium. The sludge loosened by the percussion drill is conveyed to the surface by means of a continuous water flow through the hollow cylindrical drill rod. A small gas pipe reaches a short distance down this drill rod, and through it compressed air is forced, the air bubbles into the drill rod making the water column in it lighter than that in the shaft. As a consequence the water rises into the drill rod from the bottom. Above the surface the water and sludge flow through a horizontal branch pipe from the drill rod into a basin, where the sludge is allowed to settle, the separated water flowing back into the shaft. Clay is mixed in the basin with the water returning to the shaft in order to keep the water in the shaft at the required specific gravity. During the sinking constant care must be exercised to keep this artificial level and the specific gravity of the water up to the pre-determined standards in order to prevent the caving in of the shaft. When solid rock is reached a casing is built in the usual way by means of iron tubing. In the journal mentioned there are a number of illustrations showing the details of the apparatus, which are stated to serve their purpose admirably.

The Water-Works System and Electric Lighting Station at Marietta, Ga.

The reconstruction of the water-works system and electric power station from which water and electric power for lighting are respectively supplied to the city of Marietta, Ga., is a good example of the adaption and elaboration with small funds of existing works to meet increasing demads for service. Marietta is at the base of Kennesaw Mountain and is much higher than the surrounding territory. The water supply was formerly drawn from a stream some three miles from the city and pumped through a 10-in. riser main against a head of 270 ft. to a 30x50-ft. steel standpipe on an elevation at the edge of the city and about 96 ft. above the business district. The generators furnishing electric power for lighting are installed in the power house of a paper mill in the city. This mill, the water works and the electric lighting system are all owned and operated by the Georgia Mfg. & Public Service Co. The reconstruction of the two public service systems included the augmentation of the water supply and the complete rearrangement of the power plant of the paper mill to permit additions to be made in the electric generating equipment.



River Crossing of Pipe Line and Pumping and Filter Station of Marietta Water Works.

The stream from which the water supply was formerly drawn had its source in a number of springs which afforded a flow at the pumping station of over 1,000,000 gal. in 24 hr. Two reservoirs which existed at the station, one with a capacity of 1,000,000 gal. and the other of 2,800,000 gal. enabled a consumption considerably in excess of the flow of the stream to be met for short periods. The growth of the city and the necessity for extending the distribution mains of the water-works system required more water than could be supplied by the stream that was being utilized. The only other water supply available within a radius of eight miles of the city is a stream which is fortunately only one and a quarter miles from the original pumping station. This stream has a dry weather flow greater than that required by the existing service and at the same time the water from it is of better quality than that from the existing source. The stream is at such an elevation that water could be brought by gravitation through a pipe line to the original station. Furthermore, reservoir sites which would permit the storage of approximately 50,000,000 gal. existed on the watershed of the stream above the point where an intake for such a pipe line could be built. Accordingly, this additional supply was secured, a 12-in. pipe line, 1½ miles long, was laid to the original pumping station and a new pumping station and a mechanical filter plant were built near the latter.

For the present, none of the four reservoirs which would make the 50,000,000-gal. storage available on the new stream have been built. An intake was built on that stream, however, below the location of the dam which would develop the reservoir site farthest downstream. The pipe line was built from this intake to a point about 400 ft. from the existing station, and by following more or less closely the contours of the hills, was laid without any heavy trenching. At points where the line crosses low places the pipe is carried on reinforced-concrete pedestals, which are placed 12 ft. apart so that each 12-ft. length of the cast-iron pipe of which the line is built is carried by one pedestal. These pedestals have a cross-section of 12 x 12 in. at the top, are battered ½ in. to the foot on the sides at right angles to the axis of the pipe and are reinforced with wire. They were cast in moulds on the ground and then set in place. The pipe is attached to them by a metal collar set in the concrete. No difficulty has been experienced with them in service, although some of them are over 12 ft. high, and each one carries a load of approximately 1,000 lb. when the pipe line is running full.

The original pumping station is in a brick building close to one of the reservoirs. It contains two tubular boilers, one of 80 h.-p., and the other 100-h.-p. capacity. These boilers supply steam to two compound Stillwell-Bierce & Smith-Vaile steam pumping engines each capable of elevating 1,000,000 gal. of water in 24 hr. against a static head of 270 ft. These pumps have suctions in a 7-ft. circular wet well supplied through a 10-in. pipe from an intake in one of the reservoirs, and also in a 7-ft. well supplied from the filter plant. They discharge into the 10-in. riser main leading to the standpipe above the city.

The new pumping station and filter plant are combined in the same building which is about 350 ft. from the original station. This structure is 32 x 35 ft. in plan and has a concrete substructure surmounted by brick walls and covered with a timber roof. In the rear of this building and built continuous with its sub-structure is a 26x32-ft. sedimentation basin, with a capacity of 50,000 gal., in which the solution of sulphate of alumina that is used as a coagulant is applied. This sedimentation basin is supplied through a connection with the 12-in. pipe line from the new source of supply, which connection is arranged so the supply may be drawn also from the 2,800,000-gal. clear-water basin at the existing station. The flow through this connection is controlled by a valve in the basin which is actuated by a float on the surface of the water in the latter. Baffles are placed so that the water has to pass the full length of the basin three times to reach the inlets to the filters. The solution of sulphate of alumina is applied to the raw water in the inlet connection to the basin.

The filter plant contains three filters, each 10 x 18 ft. in plan, which have a combined capacity of 1,500,000 gal. per 24 hr. The inlet to each filter is through a 10-in. pipe in the concrete wall which separates the filters from the sedimentation basin. These inlet pipes each have a stilling chamber on the end in the filter which reduces the velocity of the incoming water and distributes the flow over the filter. The filter bed consists of 8 in. of gravel at the bottom which is overlaid by 12 in. of sand. The under-drainage system of each filter is comprised of a manifold pipe extending the length of the filter at the bottom with lateral pipes connecting with it and extending transversely to it to both sides of the filter. In these laterals are screwed brass strainers through which the water is drawn into the under-drainage system.

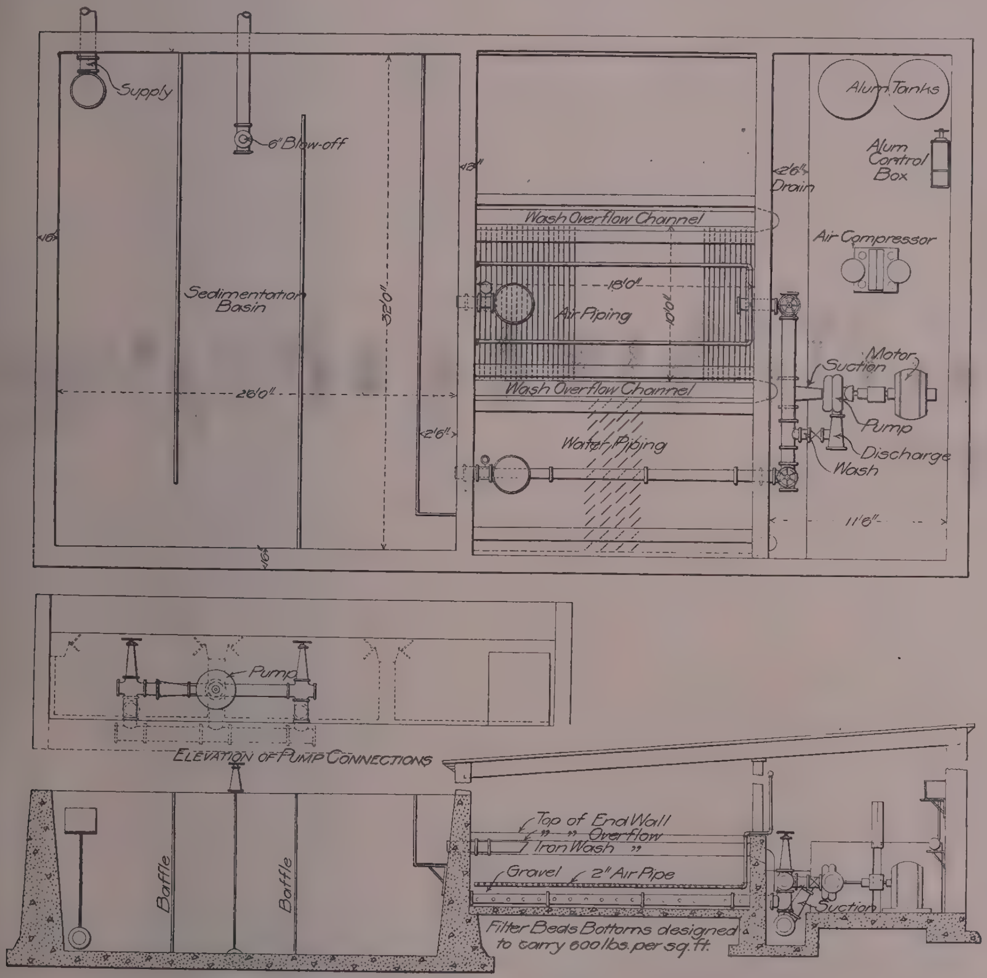
The manifold pipe of each filter is connected with a 12-in. pipe which is placed along in front of the filters and connects them directly with the suction of a four-stage centrifugal pump. This same pipe also has a valved connection with the discharge of the centrifugal pump so the flow from the latter can be diverted into the under-drainage of either filter and used as wash water. Air under pressure for agitating the sand during washing is supplied through a 2-in. pipe that is extended into each filter over the manifold pipe, just above the top of the gravel, and is connected with a system of lateral pipes. The return flow of wash water passes from the surface of the water on each filter over an overflow weir along both sides of the latter. The discharge from these weirs is carried by channels in the concrete side and division walls of the filters to a drainage channel at the ends of the filters which connects with a sewer.

The 11x35-ft. room in which the four-stage centrifugal pump is placed also contains a 12x8-in. Norwood air compressor, which supplies the air used in washing the filters and in agitating the alum mixing tanks. The four-stage centrifugal pump is of the Worthington type and is direct connected to a 150-h.-p. Westinghouse motor, electric power being furnished from the central station in the city. This pump discharges into an 8-in. force main connecting at the old station with the 10-in. riser main leading to the standpipe, or into a 10-in. main extending to a new suction well at the old station. With the arrangement of piping connections that has been secured practically any combination of supply and equipment may be secured, but under ordinary conditions the supply will largely be drawn from the new source passed through the filter plant and elevated through the force main to the standpipe by the four-stage centrifugal pump.

The mechanical equipment of the paper mill in which the electric generators supplying power for lighting are located was generally in bad condition prior to the recent addition of new generators to meet the demands for power. Steam was supplied by four 300-h.-p. boilers, fitted with Jones underfeed stokers in a brick boiler-room. These boilers were reset and their piping systems rearranged so that a considerable economy in steam consumption was secured. The machinery of the paper mill in the city was formerly supplied with power as follows: A beater engine line was driven by a 20x48-in. Corliss engine; one paper machine was driven by an 18x48-in. Cooper-Corliss engine; a second by a 14x36-in., two-valve, side-crank, Hardie Tyne engine, and two others by an 18x36-in. engine of the same type. An electric generator for lighting the plant and the city was operated by a 12x36-in. Allis-Corliss engine. In the redistribution of power, the entire layout except the driving of the paper machines is handled ordinarily from an 18x36x24-in. cross-compound condensing Allis engine, which drives the main line shaft and from that a new 225-kw., 2,200-volt, 2-phase Stanley generator which operates the general line service during the periods that the mill is running, also operating some of the widely distributed powers of the mill. The engines driving the paper machines have been re-set close to the latter and re-piped so that each machine receives its steam for drying paper from the exhaust produced by the steam engine which operates it, all drips from the dryers and other sources being returned by gravity to the boiler-feed supply. The 20x48-in. engine originally driving the main heater line, without re-setting, has been put into service as an auxiliary electric engine with a capacity for carrying the city line load as well as for supplying electrical power for operating the city water works.

The boiler plant and steam piping have been thoroughly re-arranged and a surface condenser added to be used in connection with the main engine during the operation of the mill in such a way that the hot water delivered from this condenser is utilized in the manufacturing processes of producing paper, the heat transferred from the condensers being a desirable rise in temperature for use in connection with these processes. As now planned, the water will pass first through the surface condenser and will then be used by the No. 2 and No. 3 machines which will operate on a better grade of material. The No. 1 machine running on box board will receive all its water supply from sewerage water from the No. 2 and No. 3 machines, so that no fresh water will be required in this machine.

The reconstruction and extension of water works, electric light system and the paper mill were carried on under the direction of Messrs. Joseph H. Wallace & Co., industrial engineers, of New York City.



Filter Plant of the Water Works of Marietta, Ga.

The Timber Used in the Mines of the United States in 1905 is the subject of a bulletin recently issued by the Forest Service, the statistics having been gathered in co-operation with the U. S. Geological Survey. The 5,000 mines reporting used a total amount of round and sawed timber equivalent to 200,000,000 cu. ft. of round timber or 2,400,000,000 board feet of sawed timber. Of the soft wood used, pine constituted one-half of the round timber, and one-third of the sawed timber, fir and hemlock being next in importance. Oak was the most important hardwood used.

Illinois Coal Tests.

A paper read before the Illinois Society of Engineers and Surveyors by Mr. Henry B. Dirks.

In Illinois, a State which ranks second in coal production in America, with an estimated coal area of 42,900 square miles, a larger area than is included in the coal fields of any other State, it is not remarkable that there should be manifested such a great interest in all questions regarding fuel. Indeed, it is surprising that this was not awakened earlier in the history of the State, for it has only been within the last fifteen years that any considerable interest has been taken, whereas the coal fields of the State were the first to attract attention in the United States, they having been mentioned as early as 1679 in the journal of Father Hennepin, the French missionary. The actual production of coal, however, seems to date from 1833, when 6,000 tons was mined in St. Clair County, and hauled by wagons to St. Louis. From that date the growth of the industry has been truly remarkable, the yearly tonnage having increased to a million tons in 1864, 10 millions in 1883, and 38 millions in 1905, with an estimated value in the latter year of $39,750,000 or about $1.04 per ton.

It is, however, not only with the production of coal that Illinois is concerned, but also with its consumption. While there have been no accurate records of coal consumed in the State, still the fact that Illinois stands as the third manufacturing State in the Union would seem to indicate that it is also a large consumer. So that, while the engineer is necessarily concerned with the knowledge of locating coal and studies designed to furnish data regarding gas in the coal, the character of the roof, of the floor and similar characteristics which condition the methods of working, still it is primarily the utilization of the coal with which he is most concerned, the others being questions to be decided by the geological surveys.

On the utilization of the coal, its composition will of course have an important bearing, and it is this fact which has brought about a closer study of coals from different districts, disclosing not only their physical characteristics, but also their chemical analysis, both proximate and ultimate, and their heat value. The results of such studies have been published by the Bureau of Labor Statistics in 1902, and by the University of Illinois in a bulletin by S. W. Parr in 1904, and more recently still in a bulletin on the composition and character of Illinois coals issued by the Illinois State Geological Survey.

As previously stated, the composition and heat value of the coal determine its value for one use or another, and not, as has sometimes been specified, and probably is still being made a feature of specifications, the number of pounds of water it will evaporate when burned under a boiler. The evaporation secured is a quantity which is influenced much more by any one of a number of causes other than that due to a variation in the fuel. However, the adaptability of certain fuels to conditions as they exist in different plants must not be lost sight of, and the size of coal and most economical ash content should be determined for all steam plants, and then coal specified accordingly when contracting for fuel.

It is probable that as a rule Illinois coals are underrated, as regards their heat value. Of 355 analyses reported by the Chemistry Department of the University of Illinois the average heat value is 12,400 B.t.u. per pound of dry coal. Of 54 Illinois coals tested in the Boiler Division of the United States Geological Survey's coal testing plant at St. Louis, the average heat value was 12,250 B.t.u. per pound of dry coal. The results of these 54 tests are of interest as they show what may be expected with Illinois coals. Some average results follow:

Ash in coal, per cent	15.0
Sulphur in coal, per cent	3.6
Force of draft over fire, in. water	.20
Rate of combustion; lbs. dry coal per sq. ft. of grate surface per hour	22.5
Flue gas temperature, deg. F	560
Equivalent evaporation from and at 212 deg. per lb. of dry coal, lb	7.53
CO_2 in dry flue gas, per cent	8.54
Clinker in the ash, per cent	46.9
Carbon remaining in the ash, per cent	18.8
Heat absorbed by boiler, per cent	60.7
Heat lost up the stack, per cent	17.9
Dry coal per elec. h.-p. developed at the switchboard, lb	4.52

The above results were obtained with hand-fired plain and rocking grate furnaces, under a Heine 210-h.-p. water-tube boiler. The steam generated was used by a 250-h.-p. Allis-Corliss simple non-condensing engine belted to a 200-kw., 240-volt Bullock generator.

Another series of boiler tests with Illinois coal which tend to show what may be expected of them are those which have been conducted from time to time by the Mechanical Engineering Department of the University of Illinois. These tests, made between the years 1894 and 1905, have been compiled and issued by the Engineering Experiment Station of the University. The tests number 162 and were made on horizontal-tubular and water-tube boilers. In the table some results of this series have been reproduced, being grouped according to the type of boiler and grate used in the tests. An interesting comparison might be made of these results with the average results obtained by the United States Geological Survey as previously given. We found the average equivalent evaporation per pound of dry coal in those tests to be 7.53 lb., whereas the average in the table is about 6.22 lb., the heat value of the coals in the two cases being respectively 12,250 and 11,750 B.t.u. It is evident that the difference in heat value is not alone responsible for the large difference in evaporation and the conclusion come to is that greater care was exercised in obtaining conditions most suited to the particular coal. But if such conditions are available in one place, they must also be at others and the conclusion is reached that in the average plant the maximum results with Illinois coals have not been realized, but that with more attention paid to the firing room they may be realized. A comparison of flue gas temperatures seems to indicate a higher temperature than 500° desirable, 560° being the average of the St. Louis trials, and the highest single results of the table also indicating flue-gas temperatures higher than the average.

COMPARISON OF RESULTS OF BOILER TESTS WITH ILLINOIS COALS ON HORIZONTAL TUBULAR AND WATER-TUBE BOILERS.

Type of Boiler and Grate.	No. of Tests Aver.	No. of Coals Aver.	Aver. Force of Draft.	Aver. Flue Gas Temp.	Dry Coal per sq. ft. of Grate Surface per hr.	Horse-power		Equiv. Evap. F. and A. 212°				
						Developed by Boiler.	Per cent of Rating Developed.	Per sq. ft. of Heating Surface pr. hr.	Per lb. of Dry Coal.	Per lb. of Combustible.	B. T. U. per lb. of Dry Coal.	Eff. of Boiler and Grate.
Water-Tube Roney stoker	9	5	.214	605	22.7	305	105	3.57	7.32	8.53	13034	54.2
	9	5	.214	605	22.7	305	105	3.57	7.32	8.53	13034	54.2
	Highest Single	1	.166	656	26.5	....	132	4.55	7.75	9.21	12364	60.5
Water-Tube chain grate	46	9	.493	521	27.2	180	98	3.43	6.29	7.82	11562	52.5
	Highest 10	4	.571	507	26.1	202	106	3.76	7.33	9.01	11821	59.9
	Highest Single	1	.710	592	23.9	....	109	4.18	7.66	9.64	11067	66.9
Hor. Tubular rocking grate	6	4	.323	473	20.5	121	113	3.70	6.81	7.95	11809	55.7
	6	4	.323	473	20.5	121	113	3.70	6.81	7.95	11809	55.7
	Highest Single	1	.257	519	18.2	117	117	4.00	7.38	8.30	11250	63.4
Hor. Tubular plain grate	45	10	.267	534	11.5	45	95	2.45	6.38	7.48	11532	53.4
	Highest 10	5	.354	542	13.4	52	123	3.16	6.91	7.85	11797	56.6
	Highest Single	1	.405	549	13.6	....	130	3.37	7.05	7.78	11430	59.6
Water-Tube plain grate	39	19	.400	509	20.6	176	79	2.62	5.75	6.67	11608	47.8
	Highest 10	4	.404	552	21.6	220	92	3.28	6.64	7.85	11728	54.7
	Highest Single	1	.790	616	25.1	507	98	3.38	6.85	8.39	11427	57.9
Water-Tube Murphy Furnace	18	5	.530	488	18.3	189	76	2.53	5.87	6.64	.....	....
	Highest 10	4	.516	481	19.1	205	82	2.75	6.11	6.92	.....	....
	Highest Single	1	.580	481	18.4	205	82	2.76	6.36	7.09	.....	....

However, it is not only in the generation of steam that Illinois coals may be utilized. In tests made at the United States Geological Survey coal testing plant at St. Louis to determine the adaptability of Illinois coals to power-gas producers, it has been found that they may be used with very good results. It was found that, although coals high in sulphur and ash were used, they caused no serious trouble in the operation of the plant. One test on Illinois coal was run continuously for about 28 days, with an average electrical horse-power of about 220, the producer being rated at 250 h.-p.

Following are a few average results obtained on gas producer tests with Illinois coals, of an average duration of 50 hours:

Slack.

Average B.t.u. per cu. ft. of gas	130
Average dry coal per elec. h.-p. developed at the switchboard, lb.	2.53

Nut and Egg.

Average B.t.u. per cu. ft. of gas	147
Average dry coal per elec. h.-p. developed at switchboard, lb.	1.75

Lump.

Average B.t.u. per cu. ft. of gas	150
Average dry coal per elec. h.-p. developed at switchboard, lb.	1.58

These results were obtained with the Taylor pressure gas producer furnished by R. D. Wood & Co., of Philadelphia, and its capacity was rated 250 h.-p. The gas engine used in connection with the tests was a three-cylinder vertical Westinghouse, with cylinders of 19 in. diameter and a 22-in. stroke, rated at 235 b. h.-p. The engine was belted to a six-pole 175-kw. Westinghouse direct current generator.

The gas producer as first installed had a purifier to eliminate the sulphur in the gas; however, it was found that more or less sulphur was passing the purifier and entering the engine cylinders, and after investigation the purifier was entirely removed with no ill effects being discovered, though coal has been used containing as high as 8.1 per cent. of sulphur. The results certainly indicate the apparent advisability of using Illinois coals in power gas producers, the ratio of economy of the steam unit to the gas unit being as 1.95 to 4.52, under the conditions that obtain at the St. Louis plant.

The government coal testing plant at St. Louis has also made tests on the washing and coking of coals. Of fourteen tests made to determine the effect of washing Illinois coals the following results are the average:

Slack.

Ash in unwashed coal, per cent	17.8
Ash in washed coal, per cent	8.3
Decrease in ash due to washing, per cent	9.5
Sulphur in unwashed coal, per cent	3.19
Sulphur in washed coal, per cent	2.67
Decrease in sulphur due to washing, per cent	.52
Refuse due to washing, per cent	18.2

Run of Mine.

Ash in unwashed coal, per cent	12.2
Ash in washed coal, per cent	8.1
Decrease in ash due to washing, per cent	4.1
Sulphur in unwashed coal, per cent	3.50
Sulphur in washed coal, per cent	2.84
Decrease in sulphur due to washing, per cent	.66
Refuse due to washing, per cent	14.4

Lump.

Ash in unwashed coal, per cent	10.8
Ash in washed coal, per cent	7.8
Decrease in ash due to washing, per cent	3.0
Sulphur in unwashed coal, per cent	2.93
Sulphur in washed coal, per cent	2.31
Decrease in sulphur due to washing, per cent	.62
Refuse due to washing, per cent	15.5

From the above it is seen that while the ash content is decreased 3 to 10 per cent., with different coals, the percentage of refuse runs as high as 18. The difference between the two percentages evidently represents the loss of coal due to washing and in the tests cited varies from 8.2 to 11.9 per cent., quite an appreciable loss. While some tests have been made with washed coals under steam boilers, there have not been enough to enable conclusions to be drawn. And even had there been sufficient to indicate conclusions regarding their evaporative efficiency, the question of the economy of washing would still be far from settled, as it is dependent on several other factors, such as the decrease in freight costs due to non-shipment of the ash removed from the coal, decrease in cost of handling ash, increase in cost of coal, etc., which would no doubt have as much or more weight in determining the question than does the evaporation. The effect of washing on the evaporative efficiency of coal is, however, being investigated by the Fuel Tests Division of the Engineering Experiment Station of the University of Illinois, a very complete series of tests having been arranged with washed and unwashed coals of the same size and coming from the same district, so that the tests should admit of some conclusions.

The coking tests with Illinois coals have not been very successful, the average results of six tests being as follows:

Yield of coke, per cent	50.2
Ash in coke, per cent	15.3
Sulphur in coke, per cent	2.1

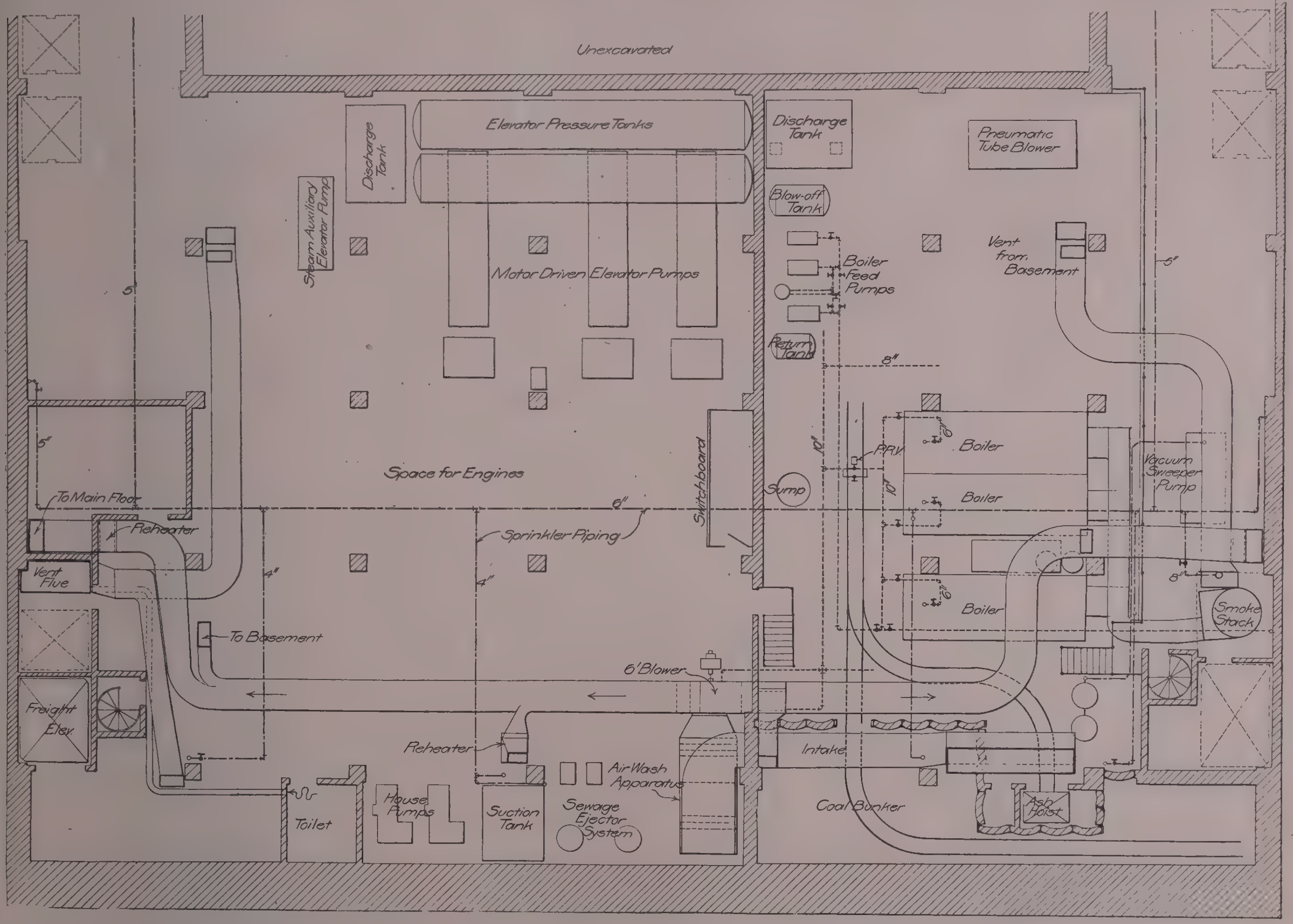
The coke has been of poor physical quality and is too high in sulphur and ash to make good blast furnace coke.

In conclusion a few remarks regarding the smoke problem applied to Illinois coals will not be out of place. These coals and all bituminous coals will produce smoke if the gases as they are driven from the coal are immediately allowed to mingle with the cold tubes. However, in a furnace so constructed that the gases driven from the coal pass along a hot tile roof and mingle with air in the combustion chamber before the heating surface is reached, it is almost certain to result not only in complete combustion of the gases and the avoidance of smoke, but also in increased economy. A coking arch above the front end of the fire is also an essential part of the furnace for bituminous coals, as is also the uniformity in feed of coal and conditions of the fire, which latter, however, are obtainable with most of the modern stokers.

The tile furnace roof is easily obtained in most forms of water-tube boilers by placing special fire-clay tile around the lower row of tubes. A considerable number of such tile roof furnaces are in successful operation, which fact indicates that Illinois coals can be burned without producing excessive smoke if the proper precautions are taken.

The Heating, Ventilating and Electrical Equipment of the Claflin Building, New York.

The Claflin Building is a ten-story and basement steel and brick structure which has recently been completed on 34th St., New York City, near Fifth Avenue, for the dry goods and department store of James McCreery & Co. The building has a frontage of 150 ft. on 34th St., and a depth of 200 ft., extending through to 35th St. at the rear. It is occupied from the basement to the eighth floor inclusive, for salesrooms of the store, the ninth and tenth floors and a portion of the eighth floor and basement being devoted to the auxiliary services of the store, including altering and repair departments, offices, locker and lunch rooms, and packing and shipping. Under the rear portion of the basement at the 35th St. end, a sub-basement has been excavated, 90 x 150 ft. in size, in which is located the mechanical equipment of the building including power plant and auxiliary machinery. An unusual feature of the building is that each of the retail floors is a single area, 150 x 200 ft. in size, entirely unbroken by partitions, which greatly facilitates the heating and ventilation.



Arrangement of the Mechanical Plant in the Sub-basement of the Claflin Building.

An unusually complete mechanical equipment has been installed in the building, including a boiler plant for heating the greater part of the building, ventilation systems for the first floor and basement, nine hydraulic passenger elevators and two freight machines, an extensive pneumatic tube system for the cash service of the store, a complete automatic sprinkler system of fire protection, and the usual auxiliary equipment of sewage ejectors, house pumps and vacuum cleaning apparatus. The power plant installation is, however, greatly simplified by the absence of electrical generating equipment, current being furnished by the New York Edison Co., although both the steam generating equipment and the engine room were designed for the installation of sufficient apparatus to supply current for the building if it should prove desirable later. The boilers and piping are designed throughout for high pressure, although they are at present operated at medium pressure, steam for the heating system being supplied from the high pressure mains through a reducing valve to supplement the exhaust from the few steam pumps that are in use, and blanked connections on the boiler room steam header provide an easy connection to future electrical generating units. At present, very little machinery is steam driven, electric power being used for the elevator pumps, compressors, house pumps, etc. The steam-driven units consist of a reserve elevator pump, the boiler feed and blow off pumps and a few other miscellaneous pumps.

The sub-basement, which is excavated under the 35th St. sidewalk and for a distance of 90 ft. under the basement, is divided into a boiler room occupying the westerly 60 ft., and an engine and machinery room 85 ft. in width on the east. At the rear of both boiler and engine rooms, there is a 20x25-ft. extension next to the outer walls on either side, under the elevator shafts, to provide for the elevator piping and control apparatus. The engine and machinery room has a clear headroom of 15 ft., but the floor of the boiler room is depressed 6 ft. below this level to provide headroom for steam piping connections and smoke flue, with the exception of an area 16 ft. in width at the west side; this portion, which connects with the extension under the elevator shaft, is at the level of the engine room. At the street end of the boiler room there is an irregular enclosure provided for the storage of coal, which is conveniently arranged for dumping directly from wagons through coal holes in the 35th street sidewalk. Access for machinery and apparatus to the sub-basement is had through a sidewalk elevator rising from the boiler room floor to the street level and also the large freight elevator at the easterly front corner of the engine room which has a travel down to the sub-basement level.

Boiler Plant.—The boiler plant consists of three 150-h.-p. Babcock & Wilcox water tube boilers, which will provide adequately for the operation of the heating system of the building, and there is space provided for at least two more units in case of installation, in the future, of electrical generating machinery. The boilers are arranged in two batteries, one of two units between building columns and the other a single unit next to the coal bunker, this arrangement providing ample side clearance for access to fittings and for cleaning. There is a 16-ft. firing floor in front and 5 ft. space between the rear of the settings and the raised section of the floor at the rear of the room. The boilers are of the cross drum type, each having eight tube sections consisting of nine 4-in. tubes, 18 ft. long, presenting a total heating surface of 1,500 sq. ft. The steam drum is 42 in. in diameter by 6 ft. long and arranged crosswise at the rear of the setting. The settings are fitted for hand firing, with McClave shaking grates having 30 sq. ft. of grate area, which are designed for burning fine grades of anthracite fuel. The products of combustion are removed by a 2 ft. 8 in. by 6 ft. breeching at the rear of the settings, with 24x42-in. dampered connections to each boiler, all heavily covered with asbestos blocks. This breeching delivers into a 5½-ft. circular steel stack rising 210 ft. above the boiler room floor, to a point above the roof, which is enclosed in an 8x10-ft. pipe and vent riser shaft at the west side of the building. In this shaft is also carried up an exhaust riser which provides for the steam pump exhausts. The breeching connection to the stack is fitted with a swinging damper mounted on roller bearings which is operated by a Locke automatic damper regulator for control of the steam pressure.

The fuel supply is stored in a spacious bunker which has been built in the street end of the boiler room under the sidewalk space. It is formed by a strong partition of I-beam posts, spaced 3 ft. apart, with jack arches between to withstand the thrust of the coal, the partition being recessed opposite the boilers to pass around the sidewalk elevator enclosure. The bunker space has a total floor area of 640 sq. ft. and a depth of 22 ft., the capacity when filled being over 450 tons. Coal is delivered to the bunker by dumping from wagons in the street through sidewalk coal holes above the basement space, which open through chutes into the bunker space. The coal is handled to the firing floor by a steel charging car which runs on a 21½-in. gauge track extending the length of the firing floor and into the bunker space. The door-way opening to the bunker is enclosed by a steel shutter gate with outlet chute provided for dumping directly into the charging car when the bunker is filled to a considerable height above the floor. A branch track is extended to the sidewalk elevator for handling the ashes in cans to the street for removal by the city ash carts.

The boilers are fed with condensation returned from the heating system, city water being used for make-up; they are arranged to be fed either by injectors or feed pumps, there being a Monitor-pattern Nathan injector on each boiler with water supply connections from the building water service piping, and two Platt Iron Works 7½x4½x6-in. feed pumps, which deliver through a feed system. The pumps are brass fitted, designed for pumping hot water, and are connected to return, under control of a pump governor, the condensation from the heating system, with auxiliary connections from the house water mains for make-up. The returns from the heating system are piped to a 3x4-ft. return tank which delivers to the feed pumps through a Kieley pump governor, which closes down the pumps whenever the return tank is drained. The boiler feed system consists of a 3-in. feed main from which 1½-in. branches are connected to each boiler. The blow-off outlets of the boilers are connected to a 3-in. main which leads to a 3½x6-ft. blow-off tank at the rear of the boiler room from which the discharge is raised to the sewer in the adoining street by a 6x4x6-in. Platt Iron Works blow-off pump, or may be discharged by gravity to a sump pit below the boiler room level, in case the pump is not in operation. The sump pit is a well 4 ft. in diameter by 6 ft. deep, which receives the drainage from the boiler room and also the ground water drainage from underneath the foundations and floors. This drainage is normally raised to the sewer level by a Tacony automatically controlled motor-driven vertical submerged centrifugal pump, although connections are provided so that the blow-off pump may serve for this purpose, if desired. The blow-off tank is provided with a cooling coil consisting of 35 ft. of 3-in. brass pipe through which the water supply to the hot water heater is passed, for partial cooling of the blow-off discharge before entering the sewer. The vapor from the blow-off tank is removed by the 4-in. riser with roof exhaust head which serves for the pump exhausts.

Piping and Pumps.—The steam piping consists of a short 10-in. boiler room header hung over the firing floor, with 6-in. branches to each of the boiler steam nozzles, and from this, steam supply connections are made to the heating system through a reducing valve, to the steam pumps and to the high pressure steam service for the kitchen and the roof tank heaters. For the latter a 1¼-in. main is carried up the pipe shaft to the roof and thence to the roof tanks, while the feed and blow-off pumps are supplied by a 2-in. main. For the heating system supply, a 10-in. Kieley reducing valve with 5 in. by-pass delivers steam to the heat distribution mains at low pressure; this low pressure main is a 10-in. header which supplies a number of heating mains that extend to various parts of the building. The high pressure piping is, like the boilers, designed throughout for operation at 150 lb., although for the present the boilers are carrying only about 80 lb. pressure.

The present equipment of the engine room consists merely of the elevator pumps and air compressors for the pressure tanks, the house pumps, a sewage ejector equipment and the main switchboard for the electrical distribution system. Ample space has, however, been reserved in the central portion of the room to provide for engines and generators without in any way restricting access to the machinery equipment. The house pumps consist of two Platt Iron Works motor-driven triplex pumps which are operated under automatic control for the supply of water to the building water service. The sewage ejector is an Ansonia sewage lifting equipment which has been installed with duplicate ejector tank and compressors for the removal of sewage from the basement and sub-basement sections of the building, which are below the normal sewer level in the adjacent street. The elevator equipment consists of three electrically driven pressure pumps and one duplex steam auxiliary pump. The elevators are all of the plunger type of the Otis Elevator Co., New York, and are operated at 160 lb. pressure. The pumps consist of 9x15-in. two-cylinder double-acting flywheel pumps of the outside-packed-plunger type, built by the Platt Iron Works, which are belt driven by 100-h.-p. Otis motors; these are under automatic control from the pressure by Sundh automatic regulators and starting rheostats. The auxiliary steam pump is a 14 and 20x12½x10-in. Worthington steam pump which has been installed for use when desired. The pumps deliver to the elevator system through two 5¾x38-ft. heavy cylindrical pressure tanks which are arranged horizontally at the rear of the engine room. Suction is taken from two 8x11-ft. open steel discharge tanks, one of which is located in the engine room and the other in the boiler room adjoining. The necessary air space is maintained in the pressure tanks by an equipment of motor-driven air compressors in duplicate, each consisting of an 8½ and 4½x6-in. two-stage Blake compressor which is chain driven by a 7½ h.-p. motor. There is installed in the boiler room a large Connersville blower for the operation of the cash tube system which is of the Lamson vacuum pneumatic type. This blower has a displacement of 103 cu. ft. per revolution and is operated for a duty of about 6,500 cu. ft. per minute by a 50-h.-p. motor.

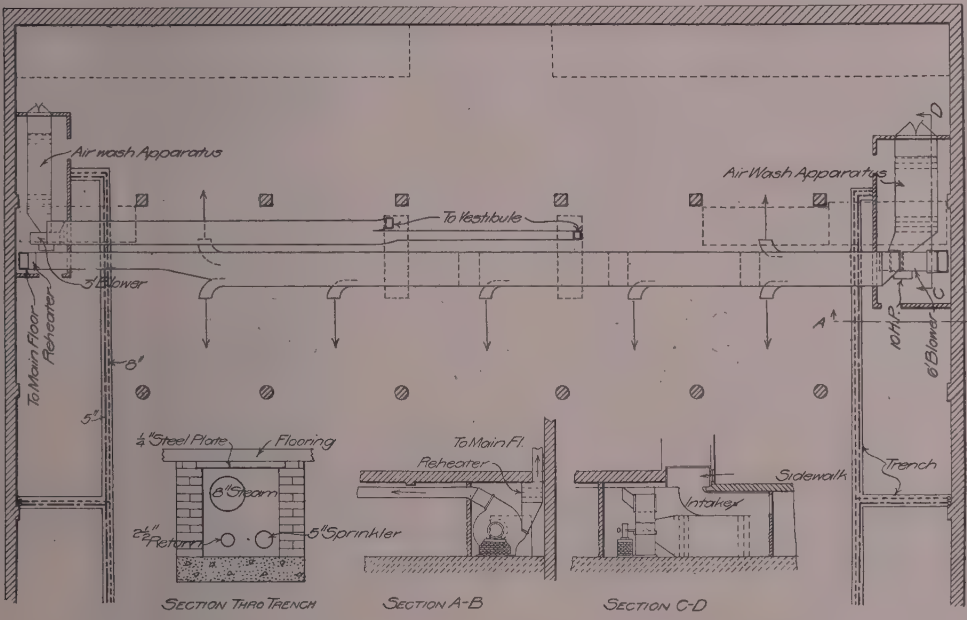
Heating System.—The building is heated throughout by direct radiation, which is supplemented by indirect heating where necessitated on the first floor by the impossibility of proper locations of direct radiation, and in the basement by the requirement for mechanical ventilation. The heating is accomplished by steam at low pressure to permit of the use of exhaust steam from steam using machinery in case the latter is at any time installed, the steam supply at the present consisting of the pump exhaust and reduced pressure supply from the boilers. The system has been designed to heat the building to 70 deg. in zero weather with a steam pressure not to exceed 5 lb., the direct radiation on the upper floors having been proportioned on the thermal unit system of heat loss and distributed to directly counteract window exposure. The installation is greatly simplified by the fact that window exposure is encountered only at the 34th and 35th street fronts of the building, the east and west sides consisting of party walls with tall buildings alongside. Practically all of the radiation is distributed underneath the front and rear windows on all floors, but there are provisions for radiation at two points along each side wall to provide for losses through the party walls, which has in but few cases been there found necessary. On the top floor, the lighting of the work shops and altering departments is accomplished by a number of skylights in the roof, the exposure of which is counteracted by pipe coils of 1¼-in. pipe encircling the skylight openings at the base.

A typical arrangement of radiation on the upper floors is shown in the plan of the fifth floor. At the 34th St. front, two radiators are placed under five of the seven groups of windows consisting of two 104 sq. ft. radiators in each case, or 1,040 sq. ft. to counteract the front glass exposure; on the upper floors the radiation for similar locations is increased somewhat. At the northerly front of the building facing 35th St., radiators are provided under all the groups of windows on each floor, consisting of 84 sq. ft. of radiation in the enclosed stair wells at either rear corner, and two 84 sq. ft. radiators under each of the five remaining window groups in the store proper, with the exception of the wider window at the middle which has two 120 sq. ft. radiators; this radiation is similarly increased slightly on the upper floors as for the front of the building. The radiation provided for in the center of each floor consists of a single radiator at the side wall both in front and at the rear of the group of elevators on either side; the provision of radiation at these points was merely as a precautionary measure as the effect of the exposure is there very slight, and in most cases the radiators have not been installed, not having as yet proved necessary.

The radiation is operated on the two-pipe system with gravity returns, steam being distributed by fourteen riser lines, four of which are located on the 34th St. front and supply the radiation in that portion in four groups, two of which are at either side wall next to the elevator shafts, and six at the 35th St. front, two of which serve the rear stair well radiators and the other four the groups of window radiation in the store proper. These risers vary in size from 2 to 4 in., tapering toward the top, and each is dripped at its lower end to the return lines for drainage of condensation. They are anchored to the building construction at the middle of their length and left free to expand thence in either direction, and all radiator branch connections are run exposed above the floor construction. Steam is delivered to the risers from the low pressure header in the boiler room by three 8-in. branch mains, one leading to the easterly wall and front, another to the westerly wall and front, and a third to the rear of the building. The mains extending to the front portion of the basement are run from the sub-basement through the unexcavated space under the basement, in floor trenches 30 in. wide by 36 in. deep, which end in the fan rooms in the front corners of the basement. The return system embraces a similar arrangement of risers and mains which parallel the lines of the supply system, with risers and connections in general of sizes one-half of those for the supply. There is in addition an air valve system for the removal of air from the radiation, ¼-in. connections to the air valves of the radiators leading to ¾-in. risers which parallel the supply risers, and connect into 1-in. and

1¼-in. gathering mains in the basement.

Indirect Heating.—In the basement and on the first floor, the heating is accomplished by the hot blast systems installed on account of lack of available space in the latter for convenient locations of radiators and also owing to the greater necessity of ventilation in these portions of the building. To counteract the cooling effect in the first story of the cold draughts admitted through the main entrances in winter time, hot blast systems are installed to supply large volumes of hot air to the entrance vestibules which will have the effect of mixing with the cold draughts and producing a resultant temperature that will not be uncomfortable in the interior. To provide the hot blast, there are three blower systems installed, one at the 34th St. front of the building and another for the 35th St. front, for heating the main floor and basement, while a third at the 34th St. front is devoted solely to the supply of hot blast to the entrance vestibule enclosures at that end. A feature of the systems supplying the basement and main floor is the use of reheating systems in the ducts to the latter, it being desirable to deliver the hot blast to the main floor at higher temperatures than for the basement. As the fans have fresh air intakes through gratings underneath show windows on the street fronts, the systems are fitted with air washing apparatus for purification of the air drawn in.



Details of Fan Equipments in Basement for Indirect Heating.

The two systems at the 34th St. front are installed in small enclosures in the basement under the front corners of the building, where convenient to the intake connections and short direct connections to the ducts and flues are permissible. The vestibule system at the easterly side has a 16-in. by 18-ft. intake from underneath the easterly show window and delivers to the vestibule through a 16x34-in. rectangular duct on the basement ceiling, with 16x24-in. risers to the vestibule outlet gratings under show windows on either side. The larger system at the westerly side has a 2x35-ft. intake through gratings under two of the 20-ft. show windows and has double discharge connections, one connecting directly to a 24x40-in. flue leading to the first floor outlet register directly above and the other connecting with a 20x63-in. rectangular ceiling duct, which extends across the basement and ends in a second 24x40-in. flue rising to a register at the opposite front corner of the main floor above; this duct has also seven openings into the basement, five discharging to the rear and two into the space underneath the sidewalk. The 35th St. system apparatus is located in the sub-basement and has a 32-in. by 15-ft. intake underneath show windows above, the fan being of the double horizontal discharge type. From each of the outlets a 24x45-in. delivery duct extends on the sub-basement ceiling to either side of the store to 24x48-in. flues which rise to corner outlet registers on the first floor level and to 18x36-in. risers supplying the rear of the basement on either side; also connections are made to two 16x27-in. risers for the hot air supply to the smaller 35th St. entrance vestibule. The plan of hot blast delivery to the store consists of outlet registers at each of the four corners of the main floor, and, in the basement, distributed duct openings at the front and corner outlet registers at each of the rear corners, while the hot blast to the vestibules prevents uncomfortable draughts into the main floor. Each of the 34th St. systems has bypasses in the fan intakes which permit of recirculating air from the basement for night heating or in case of extreme cold weather when it is not desired to take in the cold outside air.

The blowers are of the full-housed steel-plate centrifugal type, built by the American Blower Co., that for the 35th St. front vestibule system having a 3-ft. wheel, 18 in. wide, and the other two each a 6-ft. wheel, 3½ ft. wide. They are belt driven by C. & C. motors; the two 6-ft. fans, which have capacities of 21,000 cu. ft. per minute at 200 r.p.m., by 10-h.-p. motors, while the 3-ft. vestibule fan is driven at 600 r.p.m. by a 5-h.-p. motor and delivers 6,500 cu. ft. per minute. The use of air washing apparatus in each case permitted a most economical intake arrangement, allowing air to be taken in directly from the street level without the trouble from dust or dirt that would otherwise be encountered, and obviating the necessity of large cheesecloth filter apparatus or intake shafts for drawing in from the upper levels. The air washing apparatus is of the spray type, built by Thomas & Smith, consisting of a steel chamber with numerous water spray jets through which the air is drawn from the intake at a greatly reduced velocity to cause it to come into thorough contact with spray before entering the fan. The spray is caught in a steel pan below the spray chamber from which the water is recirculated through the sprays by means of a small centrifugal pump belted to the motor driving the fan. Water is maintained at an even level in this spray pan by means of a float valve, and dirt is prevented from entering the pump by means of a series of strainers; this water is recirculated continuously for a week or more at a time, being changed only as dirt drawn in from the street accumulates. Between the sprays and the fan intake, are located a group of baffle plates or eliminator for the removal of entrained water from the passing air.

The heating coils of the fan systems are installed in two sections, one consisting of the tempering coil in the intake to prevent freezing the spray in severe weather, and the other, the main heating coil between the eliminator and the fan. The tempering coils of the two larger systems contain 480 sq. ft. of radiation and that for the 34th St. vestibule system, 196 sq. ft., the main heating coils of the two larger systems containing 720 sq. ft. and that of the vestibule system, 480 sq. ft. These coils are of the vertical four-row section type of the American Blower Co., consisting of 1-in. pipe screwed into cast-iron headers, and are supplied with steam under the automatic control of the Powers system of the temperature regulation. The tempering coils are in all cases controlled from cold air thermostats in the air intake which turn on the steam at a temperature near freezing. The main heating coils are controled through thermostats in the delivery ducts which are set in accordance with the degree of heating required in the basement, as both of the systems supplying the main floor and basement are proportioned for proper heating of the basement only, which requires less heat than the main floor on account of its comparatively small exterior exposure. The reheating coils for raising the air supply for the main floor to the higher temperature necessary, are installed in the flues which rise to the main floor registers, and contain 200 sq. ft. of heating surface for the 35th St. corner registers and 175 sq. ft. for those at the 34th St. front. Similarly, the supply to the 35th St. vestibule which is taken from the rear heating system is reheated for a high temperature supply, by a reheater in each of the flues, containing 135 sq. ft. The reheating coils are in all cases controlled from thermostats located in the main floor or in the rear vestibule where average temperatures are obtained.

Ventilation.—Mechanical ventilation is provided for the basement, the boiler room and the toilet rooms on the upper floors, which are located on either side of every floor next to the rear stairways. The boiler room ventilation consists of a fresh air supply for cooling in warm weather, which is operated by a 42-in. Blackman disc fan, having intake from the sidewalk level through the ash hoist shaft; it is located in the shaft enclosure partition and blows air directly to the boiler room, giving satisfactory results in a cool and comfortable boiler room. The basement and toilet ventilation is operated by two 60-in. vertical Blackman disc fans located in pent houses on the roof, one over each stairway enclosure, which draw through flues from the basement, with intakes from two sections of the latter floor and from the toilet rooms on each floor. The flues to the disc fans consist of a 4x8-ft. shaft at the easterly side and the enclosure surrounding the smoke stack on the westerly side, from which the vent connections to the toilet rooms on each floor are mere openings through partitions. The exhaust connections to the basement consist of ducts carried on the sub-basement ceiling from the bases of these vent shafts to flues rising near the central portion of the basement to two 30x36-in. registers in the shipping room section and to two 36x42-in. registers in the salesroom portion of the basement. The latter have, however, been closed off, having been found unnecessary in that portion of the basement on account of the location of the 63-tube central station of the cashier's pneumatic tube system there, which system is of the suction type and effects an exhaust from the atmosphere of the basement of over 7,000 cu. ft. per minute. The roof exhaust fans are located nearly over the tops of the vent flues for short connections and discharge directly through copper roof hoods. Each of the disc fans are driven at 350 r.p.m. by a 6-h.-p. vertical shaft C & C motor, the fans having a capacity at maximum speed of 28,000 cu. ft. per minute. The boiler room ventilating fan is driven at 500 r.p.m. by a 3-h.p. direct-connected motor.

Electrical Equipment.—The use of electricity is unusually extensive in the Claflin building for both power and lighting. Practically all of the auxiliary machinery of the building, not only in the power plant but also for the store service, is electrically driven, including the pumps of the hydraulic elevator system. The current is obtained from the New York Edison Co., and in order to insure continuity of the current supply two feeder cables are brought into the building which connect with different underground distribution lines originating in separate sub-stations of the Edison Co. The two service connections consist each of six 1,250,000 c. m. feeder wires, which are carried to a five-panel marble switchboard in the engine room in the sub-basement from which the distribution is controlled. The current supply is on the Edison three-wire system and accordingly the building is wired on the three-wire system for the lighting, with two-wire circuits for all motors. The supply feeders are controlled by double-throw three-pole knife switches on the Edison service panel and terminate in three-pole knife switches of large capacity, located on the central panel together with volt meters for the two sides of the system. The two panels next to the middle are for the power circuits while the outside panels carry the lighting feeders. The circuits on the feeder panels have been so distributed that the two panels on one side control the power and lighting for one half of the building and the two on the opposite side, the power and lighting for the other half, and each side has an independent set of bus bars which may be thrown on to either supply feeder from the street.

The wiring of the building is in loricated conduit throughout, the power circuits extending from the board direct to the motor starting boxes and the lighting feeders to the three local distribution panel boxes on all floors. The conduits start from an enclosed slate pull box immediately above the rear of the main switchboard, on which connections are made to the feeders by heavy bare copper cables carried up from the switch terminals at the rear of the panel. The feeders, mains and branches are run ordinarily with all three wires in a single tube, but with the larger sizes of feeder cables a single tube is devoted to each wire for ease of pulling in. At the panel boxes connections are made to branch circuits on double panel boards of slate, which are enclosed in metal boxes with slate-lined covers. The feeding points for the upper floors are at opposite side walls toward the front of the building and at the east wall toward the rear, there being three feeding points with the panel board for local distribution on each floor. Each panel board is fitted with enclosed fuses and snap switches for the control of lighting, and the snap switches have, instead of the usual flat handle, a catch to receive a special turning key to be inserted through a small hole in the enclosing door; this permits of the lights being operated only by heads of departments or those in possession of keys, the panel boxes being kept locked at all times.

The lighting of the building is accomplished in general by arc lamps, supplemented by incandescent lamps distributed as required for special illumination in show cases, displays and in offices. The building is conveniently laid out for proper distribution of illumination; the rows of columns form bays 20 ft. square and a single 2,000 c.p. lamp is provided in the center of each of the bays, which gives a resultant average intensity of illumination of 5 candles per square foot. Every arc lamp is wired on a separate branch circuit from the controlling panel board, the conduits for which are installed in the ceiling, and arranged as shown in the seventh floor plan. Extension plug outlets are also provided at practically all of the building columns on each floor which are wired through conduits under the floor, the outlet boxes being so located as to suit special show case wiring.

The power equipment consists of 22 motors, ranging from 2 to 125 h.-p., and a large number of smaller sizes for minor purposes. In the basement there are three 125-h.-p. motors driving elevator pumps, a 50-h.-p. motor operating the blower for the vacuum pneumatic tube cash system, a 20-h.-p. motor driving the vacuum sweeping apparatus, three 10-h.-p. motors operating house pumps and a ventilating fan, and seven smaller motors operating air compressors and pumps. The ventilating apparatus is driven by a 5 and a 10-h.-p. motor in the basement and two 6-h.-p. motors in the pent houses on the roof, while on the 10th floor, there are three 10-h.-p. motors driving machinery in the store service. These motors are all wired on separate 200-volt two-wire circuits from the main switchboard to the starting boxes, and a number of them are under automatic control from floats or pressure valve switches. The elevator motors are each controlled through Sundh automatic starting switches of the rheostatic type by pressure governors.

The power equipment of the building and also the heating and ventilating systems were designed and installed throughout by Thompson-Starrett Co., New York. The architects of the building were Messrs. Hale & Rogers and Mr. R. B. Sherburne.

TIMBER CONSUMPTION in the United States now amounts to about 400 ft. board measure per capita, while in Europe the average is but 60 ft. The best managed German forest grows on an average about 50 cu. ft. of wood per acre annually. If American forests grew as well, which they do not, they would barely furnish by their annual growth the amount of wood now used. These figures were given by Mr. R. S. Kellogg, of the United States Forest Service, in a recent paper before the Western Society of Engineers, which was presented for the purpose of calling attention to the necessity of economy in the use of timber. Mr. Kellogg pointed out that in Europe the amount of timber required for many structures is very much less than it is in the United States, masonry of one form or another generally taking its place. In his opinion the time will come very soon in this country when the relative cost of masonry and wood will be much different from what it is now and in consequence the use of timber will be restricted far below the limit of the present time. He is of the opinion that methods of preserving timber will be employed far more extensively than today for many purposes where untreated wood is now used. One particularly useful improvement which he anticipates, will be the substitution of woods which are now considered inferior for those of high value. An example of this is the gradual substitution in wagon boxes in place of white pine, first of yellow poplar, then cottonwood, then red gum, and to-day tupelo. Readers who are interested in this subject, and all engineers ought to be, will find a large amount of interesting information concerning the quantity of timber employed for different purposes, in several bulletins recently issued by the Forest Service.

Mixing Rocks for the Wearing Surface of Macadam Roads.

The last contribution by the U. S. Office of Public Roads to our knowledge of the physical and chemical principles on which satisfactory road-building depends to a considerable extent, relates to the decomposition of the feldspars. The staff of the Office recognized early in its investigations that a thorough study of the properties of binding materials was imperative, and its experiments along this line have led to important results already recorded in this journal. The most recent work has been to determine the phenomena attending the decomposition of the feldspars; it is the subject of a report by Messrs. Allerton S. Cushman and Prevost Hubbard, just made public, from which the following notes have been taken.

When powdered feldspar is acted upon by pure water, the surfaces of the crystalline particles suffer decomposition. The action rapidly slows down, owing to the formation of clogging films of insoluble hydrated aluminum silicate, which to a certain extent absorb the alkaline bases. It would follow as a corollary of this generalization that unless modifying factors enter into the reactions, complete decomposition or kaolinization could not take place in nature. The leaching effect of water, even prolonged through geological epochs, would not suffice for the formation of the enormous bodies of residual clays in which few, if any, particles of undecomposed feldspar still remain. It can be shown, however, that such modifying factors do exist and are undoubtedly active in nature.

It is quite certain that the decomposition of the feldspars, as well as other complex silicates which appear as rock-forming minerals, can not be considered as simple cases of solution. It has been clearly shown that the absorption phenomena and the subsequent removal of the absorbed products are modified by a number of factors in the equilibrium. The development of the knowledge of these absorptions shows that all generalizations and deductions which have been made in the past, based merely upon the study of the solutions obtained after digesting rock powders and similar substances with water and dilute acids, have been in error.

The factors which modify the absorptions and amount of solution which result in the laboratory when finely powdered feldspar is acted upon by water may be subdivided under the following headings: (1) Mechanical: Effect of grinding, or some other form of attrition: (2) Chemical: (*a*) Reactions which are carried on by water alone; (*b*) Reactions in which other substances than water take part. (3) Physical: (*a*) Electrolysis with accompanying endosmosis; (*b*) Electrolysis without accompanying endosmosis.

Mechanical Effects.—As has already been stated, wet grinding of most rock powders very greatly increases their binding power. This is in line with practical experience in road building, which has shown that a liberal use of water under the steam roller is a great aid in obtaining a compact and well-bonded surface. Wet grinding permits the action of water to go farther than when the dry ground material is leached or soaked with water subsequent to grinding. This is shown qualitatively by the deeper pink color obtained with the use of phenol-phthalein upon the wet ground material. Quantitative experiments have invariably shown a much greater accumulation of decomposition products in the wet ground powders than in those which have been merely digested with water.

Chemical Effects.—Although the binding power, as has been already stated, is much increased by wet grinding and the decomposition is carried further, the amount of alkali which the wet ground material yields to water is not so large as might be expected. This is due to the absorption of the alkalies by the insoluble hydrated silicates formed, which makes it impossible to remove the soluble products completely by any ordinary means of filtration. This separation, however, has been accomplished by electrolysis and will be discussed later.

It is well known that the treatment of powdered feldspar with more or less dilute solutions of various salts leads to an increased amount of decomposition products passing into solution. It has been found that about the same quantity of soluble decomposition products could be extracted from a finely ground feldspar, by treatment with a dilute solution of ammonium chlorid, as could be extracted by electrolysis without subsequent regrinding. This subject is discussed at some length in the report.

The results of investigations in the laboratory of the Office show conclusively that the decomposing action of a strong mineral acid on the feldspar is not nearly so great as might be expected, and in fact exceds but slightly that of water alone. These results indicate what has before been claimed—that in order to explain the decomposition of the feldspars in nature it is not necessary to assume the interaction of acids. The effects produced by dilute solutions of acids and salts may be principally to set free the soluble products of hydrolysis absorbed by the pectoidal decomposition products.

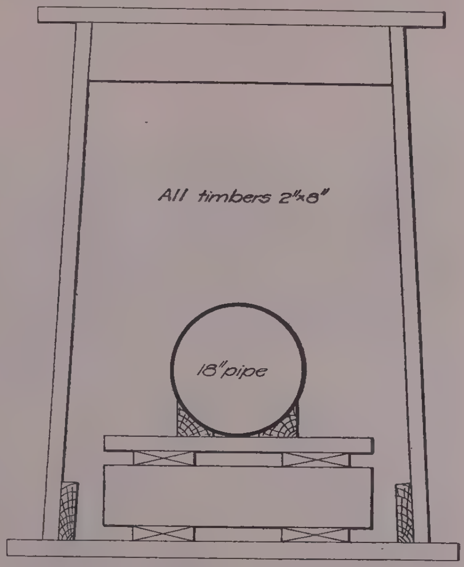
It has been noticed in cases in which macadam roads were being constructed of hard material, such as granite or diabase, which are difficult to bond under the roller, that the surface quickly compacted and gave satisfactory results when treated with a top dressing of limestone screenings. This observation suggested the trial of the cementing power of mixtures of these rocks with limestone. The test for cementing value is made in the laboratory of the Office of Public Roads by grinding the rock powder in a mill for a definite time with sufficient water to make a thick paste. Cylindrical briquettes are then molded in a die under a standard pressure, and, after gradual and thorough drying, are broken in a small impact machine. The number of 1-centimeter drops of a 1-kilogram hammer necessary to cause failure of the briquette is called the cementing value. As compared with the results of service, a cementing value of 10 is low, 20 is fair, 40 is good, and all values above 50 are excellent.

A limestone which gave a cementing value of 20 when ground wet in the mill was mixed in about equal proportions with a granite which had a cementing value of 6. This mixture when ground wet gave a cementing value of 82. Such a large increase in the binding power resulting from mixing two rocks of common occurrence is an important fact to bring out, as it has a direct bearing upon a practical problem in road building. A number of tests show conclusively that the addition of limestone to a feldspathic rock invariably increases the binding power.

The binding power of rock dusts is the result of the decomposition, or hydrolysis, brought about by the action of water. As a logical conclusion it follows that if this binding power can be increased by the addition of limestone it is caused by further decomposition of the material, brought about by the interaction of calcium hydroxid, resulting from the hydrolysis of the limestone particles. To test this point a number of granites were ground with a small quantity of limewater, and in nearly every case the cementing value was increased. The effect of dolomites upon the cementing value of granites was next tried, and while an increase was noted in almost every case, it was not as pronounced as in the granite-limestone mixtures.

In considering the action of limestone and limewater upon granites, it would seem that if the increased binding power were due to increased decomposition it would be shown by the extraction of a greater quantity of soluble alkalies from feldspathic rock powders. The results of tests bear out this inference. They were obtained by grinding orthoclase with pure lime and gypsum, and extracting weighed amounts of the mixture with water. It is very clearly shown that the admixture of lime compounds has increased the amount of alkaline bases passing into solution from four to five times. Observations that have been made in the study of plant growth furnish contributory evidence to this discussion. It has long been known that the addition of lime and gypsum exerts in many cases a beneficial effect on crops, even though lime is not to any great extent an essential plant food.

Physical Effects.—As a result of the investigations by the staff of the Office of Public Roads the following conclusions seem to be warranted:



Tunnel Timbering at Baton Rouge.

(1) Water produces an immediate though slight decomposing action upon finely ground feldspar.

(2) This reaction, due to hydrolysis, very soon slows up and almost entirely ceases, in spite of the fact that the alkaline bases set free are very soluble in water.

(3) The slowing up of the hydrolysis is due to the clogging effect of insoluble aluminum silicate, which is precipitated on the surface of the particles. In this colloidal aluminum silicate the bases are largely held by absorption instead of passing freely into solution.

(4) Wet grinding permits the action to go further by constantly abrading the particles and thus exposing fresh surfaces to the action of the water.

(5) The action of electrolytes is to set free the basic ions absorbed by the colloid decomposition products. This action is not in the nature of chemical metathesis, but is due to a change in the equilibrium conditions of the system.

In view of these considerations, it seemed possible that by electrolyzing feldspar or other rock dust slimes in a suitable apparatus, the absorbed bases could be removed and the amount of decomposition measured. It does not seem likely that electrolysis can actually cause decomposition in any other way than by removal of the reaction products from the point of formation on the surface of the particles.

The investigations of the effect of electrolysis on feldspars, with and without accompanying endosmosis, are described in much detail in the report. They resulted in the invention of a promising method of extracting practically all the potash in feldspars. The fundamental principles of this method have been made the basis of an application for a United States Patent, so that the method may be used by the federal government or any person in the country without payment of royalty. The scientific value of the experiments lies in the fact that they have revealed a method by which feldspar can be completely decomposed in the laboratory, thus proving, among other things, the truth of the opinions regarding the binding action taking place in roads when they are properly constructed.

A Deep Sewer Tunnel.

In extending the sewer system of Baton Rouge, La., the grade of the pipe, which was 18 in. in diameter, was in many places between 20 and 32 ft. below the street level. The center line having been established, shafts were sunk about 80 ft. apart, this distance being later increased to 100 ft. The shafts measuring 7 ft. wide by 9 ft. long, were sheathed with 2-in. plank held in place by 4x6-in. rangers. Grades were established at the top of each shaft, and transferred to the bottom with steel tapes. The bottom of each shaft was carried one foot below the grade of the invert, in order to provide a sump for drainage. Considerable trouble was experienced with water, which was removed by means of diaphragm pumps. The material encountered was a stiff and sticky clay, forming a good foundation when dry, but disintegrating from moisture and exposure.

From these shafts timbered tunnels 4 ft. wide by 6 ft. high, were run in both directions, the center line being transferred to the bottom by means of plumb lines. The bottom of the shaft having been covered with 2x8-in. plank, a simple portal composed of two vertical 4x6-in. sticks with a 2x8-in. cap, was built for each tunnel, and the excavation commenced. The timbering, shown in the figure, was placed without delay as the work progressed. Resistance to lateral caving was secured by placing a 2x8-in. plank beneath the cap and between the uprights, the 8-in. side being vertical. The entire frame work was securely nailed together.

The foundation for the pipe is shown in the figure. On the floor of the tunnel plank were laid longitudinally about 8 in. apart, next a 2x8-in. plank on edge, then two planks longitudinally, and on these a platform on which the pipe rests. Practically all the timbers were 2x8-in. plank. After the joints were cemented, and had been allowed to set, the tunnel was filled with earth, and well tamped.

During the construction there were several heavy rainstorms which flooded the tunnels, but no failures occurred in the work. In one place quicksand was encountered, and tuneling proved unsuccessful. An open cut, 32 ft. deep and 60 ft. long, was therefore resorted to, very heavy rangers and braces being used.

The work was done by Guild & Co., contractors, under the direction of Mr. R. Swart, city engineer of Baton Rouge.

Electrically Operated Grade Crossing Gates are in use on an electrified division of the Lancashire & Yorkshire Ry., in England, at Waterloo Station, the movements of which gates are controlled from a signal tower and interlocked with signals protecting this crossing. The gates are of a heavy double highway type, with two sets on either side of the line, swinging horizontally, and all four sections are operated by a 2-h.-p. motor which drives through a friction clutch to prevent injury to it if the gates meet an obstruction. The motor is automatically cut out and brakes applied when the gates have made their full travel either in opening or closing.

Measurements of the Resistance to Traction on Roads.

The resistance to traction on roads as determined by novel experiments was the subject of a valuable paper by Mr. C. H. Hudson before a recent meeting of the Western Society of Engineers, in Chicago. The data heretofore available on that subject were secured under conditions which no longer obtain, and dealt purely with road resistances as distinct from the resistances due to the air, axle friction, tires, etc. Mr. Hudson's experiments were made with an automobile, affording the modern conditions of pneumatic tires and high speeds, and determined the total resistance due to the road and the vehicle combined. The theory of Mr. Hudson's method is analogous to the theory of gravitation. A body projected upward loses its velocity through the retarding force of gravity, and that force produces an acceleration or retardation of 32.16 ft. per second at the earth's surface. If a moving automobile loses its velocity at that rate, the road resistance would be equal to the attraction of gravity for the mass of the automobile, or 100 per cent. of its weight. If the road resistance decreased the velocity only 3.2 ft. in one second, the retarding force would be 10 per cent. of the weight.

The experiments were made by setting the automobile in rapid motion, preferably on a level road, and allowing it to come to rest under the influence of its own momentum and the road resistance. The velocity was registered automatically, and as a loss of velocity means a proportional loss of momentum, the retarding force or resistance causing that loss of velocity can be calculated.

The recording instrument was a telegraph register such as is in common use for fire alarm calls. It had two pencils operated by electromagnets, which register in parallel lines on a tape unrolled by clockwork. One of the circuits is connected through a spring with the wheel that carries the second hand of a clock, and records half seconds; the other circuit, with a contact spring which pressed against a cam covering half the circumference of a hub of one of the wheels. The cam and contact spring, which was mounted on a small board, were the only attachments fastened to the automobile. The entire apparatus, with the batteries for operating the circuits, was mounted in an ordinary suitcase, on top of which were switches controlling the circuits.

The tests were made with an Elbridge runabout, a Jackson and a Woods car. After the car had been brought to full speed, the two circuits were closed, and the engine disconnected from the transmission. Nothing was then done until the car came to a full stop; at that moment the wheel circuit was opened and closed rapidly a number of times by hand. The register was then stopped by opening both circuits, and the tape removed. A run in the opposite direction to eliminate by comparison any irregularities caused by grade or wind, completed the experiment. It is important in such tests that the point when the car comes to rest should be accurately marked, as all calculations afterwards made start from that point as zero. The distance moved each revolution of the wheel was accurately measured by laying a tape line on the ground and allowing the wheel to make a revolution by its side.

From the recorded data a time-distance curve was platted, and a study of it shows it to approximate very closely to a third degree curve of the general form

$$D = at^3 + bt^2 + ct + d$$

By differentiation and substitution the total retarding force, R, is found to be

$$W V (3 a V + b^2) \div 16.08,$$

in which W is in terms of the same unit as R, pounds or tons, and V is velocity in feet per second. R is found as a percentage of the weight of the car by making $W = 1$. The values of a and b are determined with the aid of the equation of the time-distance curve.

The accuracy of this method, according to Mr. Hudson, compares favorably with the dynamometer method. The only thing to be adjusted is the clock, and the only measurement taken is the circumference of the wheel. The accuracy does not depend on any fine adjustments and there are no springs to measure the draught. If percentages are desired and not the actual draught in pounds, the car does not need to be weighed.

The entire set of resistances from the highest to the lowest speeds are determined by one experiment, instead of the numerous separate tests which would be necessary with a dynamometer. Moreover, this method measures the actual resistances under working conditions.

The average values of R expressed as per cent. of the weight of the car, for good level roads, were found to be as follows for different velocities:

Veloc., m. per hr.....	3.5	7	13.5	20.5	27	34
R, per. cent..........	1.80	2.06	2.50	2.86	3.20	3.49

It was found that the resistance on a badly washed macadam road in bad repair, was at all velocities 1.6 per cent. greater than those given above.

With the Reconstruction of the Havre-de-Grace Bridge over the Susquehanna River, the Pennsylvania R. R. has rebuilt and straightened 5½ miles of its Maryland Division main line through Perryville and Havre-de-Grace, Md. The improvement comprised an entirely new four-track line, with eight bridges on either side of Havre-de-Grace, for which 30,000 cu. yd. of masonry were required, and 145,000 cu. yd. of rock and earth excavation. The new Susquehanna River bridge is an 18-span, two-track bridge, with 280 ft. draw, which is located 150 ft. to the north of the old structure and required for its construction, 44,000 cu. yd. of masonry and over 10,150 tons of steel.

The Bronx River Bridge at East 233d St., New York.

The improvement of East 233rd St. between Webster Ave. and the Bronx Boulevard, in New York, includes a steel structure over the four tracks of the New York & Harlem R. R., a concrete arch over the Bronx River, and masonry retaining walls on the approaches and connecting the two structures. The length of the improvement over all is 620 ft. and the width from face to face of retaining walls at the top under the coping is 90 ft., except over the arch where the width from face to face of the spandrel walls is 98 ft., made up of a 60-ft. roadway and sidewalks of equal width on either side. The retaining walls are of rubble masonry in mortar and vary in height from 6 to 27 ft., battered on the face 1:12. The top width under the coping is 2 ft., and the backs are offset in regular 12-in. steps to the bottom, where the thickness in all cases is slightly more than four-tenths of the height.

Bronx River Bridge, Borough of the Bronx, New York City.

The steel structure over the New York & Harlem R. R., is a deck bridge 70 ft. long, made up of 24-in. I-beams, supported intermediately by steel columns placed in the center between the four tracks, and at the ends by concrete abutments. The floor system is of concrete slabs reinforced with steel bars of the Thacher type.

The interesting features of the work center in the attractive river crossing which is an elliptical concrete arch of 52-ft. span and 13-ft. rise, with a thickness at the crown of 2 ft. 9 in., and at the spring of 9 ft. 6 in. The arch ring is faced with cut-stone voussoirs which extend into the work 1 ft. 6 in. and 2 ft. 6 in. alternately, to bond with the concrete. They are fine-pointed on the soffit and rock-face in the vertical plane, with a 1-in. chisel draft on radial and a 2-in. chisel draft on all other joints.

In preparing the contract plan, provision was made for a pile foundation for the arch abutments, though bar soundings indicated that a satisfactory bottom of sand and gravel would be found, and piles would probably be unnecessary. This proved to be the case, with the result that when the excavations were made the dimensions of the abutments were modified to the extent of increasing their thickness to 15 ft. 6 in. at the base and decreasing their depth at the back by 2 ft., thereby making a more effective abutment without increasing the sectional area. The excavations were taken down at the face to a point 5 ft. below the bed of the river and the abutments of 1:3:6 Portland cement concrete in which "one man" stone were embedded, were brought up to the spring line in courses as nearly as practicable normal to the line of thrust. The arch ring is a 1:2:4 mixture and the work of placing it was carried on from each abutment toward the crown until the ring was completed.

The spandrel walls are of coursed ashlar masonry 10 ft. in height over the crown, with a width at the top under the coping of 2 ft. and at the base of approximately four-tenths of the height. All walls are coped with dressed granite. The material between the walls is of ordinary filling, except that over the arch, which was especially selected and carefully placed. The roadway is paved with macadam with gutters of Belgian block 8 ft. in width on either side. The sidewalks are flagged with bluestone.

The flow of all surface water is toward the center of the arch, where catch basins are provided on either side at the curb lines. These basins consist of a covered vertical concrete shaft, 2 ft. 6 in. in diameter, built on top of the arch concrete, and connecting at the bottom with a vertical section of 24-in. vitrified pipe passing through the arch ring and serving to discharge all the surface water into the river below. The arch is so low that the concrete soffit pierced by these holes cannot be seen from most points of view. The total cost of the work was slightly less than $75,000.

The structure, except the spans over the railroad tracks, was designed and constructed under the direction of Mr. Josiah A. Briggs, chief engineer of the Borough of The Bronx, Mr. S. C. Thompson, engineer of highways, and Mr. R. H. Gillespie, assistant engineer. Mr. W. E. Welsh was the contractor.

SMOKE PREVENTION in Paris is really compulsory, although soft coal is used largely. Mr. J. S. Neave, of Cincinnati, recently reported that the president of a cold storage company in Paris received complaints that his chimney gave out smoke. At his request an official commission examined his plant and reported that the boiler room must be remodeled and the stack lengthened 50 ft. He was given a week to make the change, but by burning coke he was allowed to defer the alterations a fortnight.

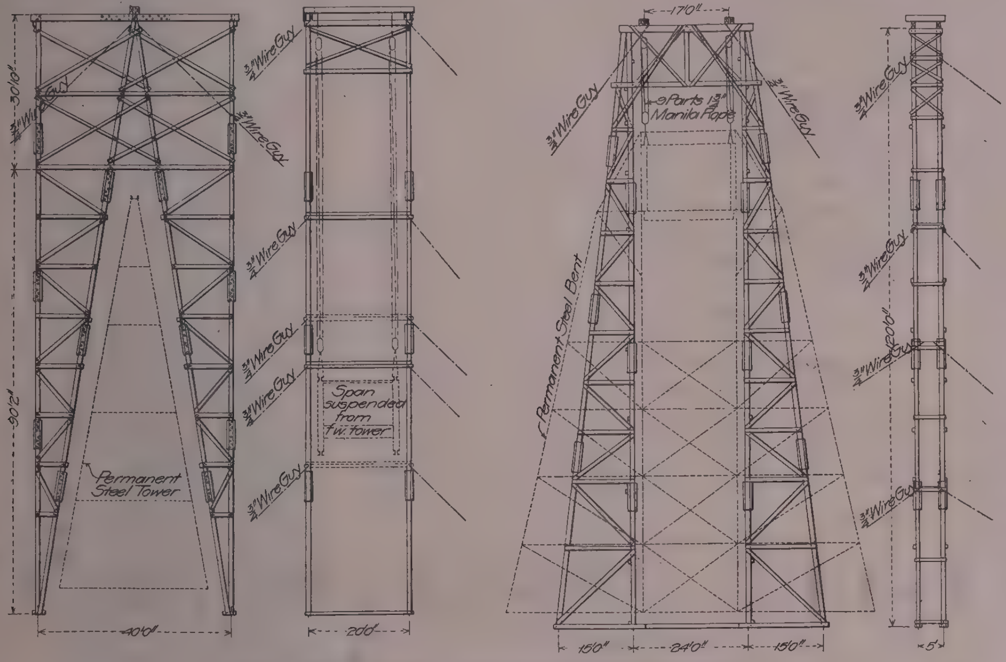
Lifting a 293 1-2-Ft. Bridge Span 85 Ft.

At the Lackawanna steel plant in Buffalo, iron ore is stored in piles from which it is removed by traveling gantries, each having a pair of horizontal pin-connected trusses about 375 ft. long. These are supported at a clear height of 85 ft. above the ground by a traveling tower near one end and a traveling single bent near the other end. The points of support are 293½ ft. apart and the truss overhangs each of them so as to leave cantilever arms on which the hoisting apparatus can travel beyond the points of support.

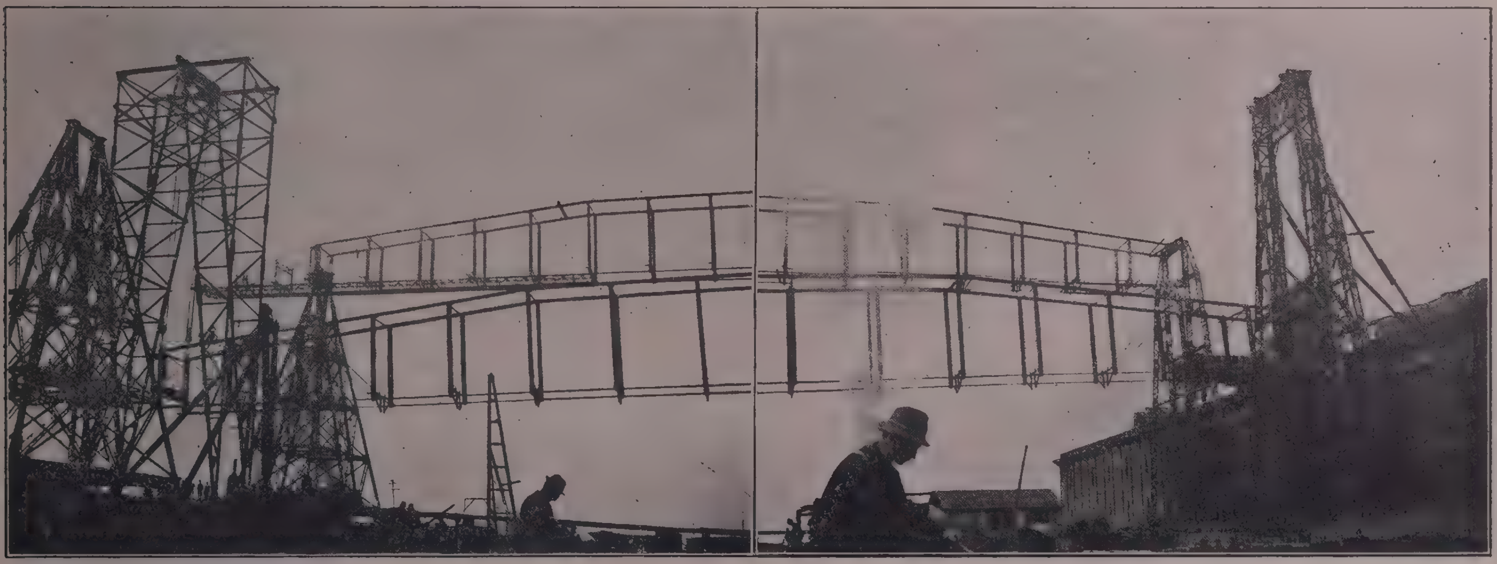
The erection of one of these gantries was accomplished with two wooden falsework towers 121 ft. high, built at opposite ends of the trusses and serving for the erection of the trusses, the permanent steel tower and the steel single bent. The latter was assembled in the position required for the support of the trusses and remained braced to the falsework tower until the completion of the job. The former had a wide base giving it abundant stability, so that after erection it was moved transversely out of position, clear of the space between the falsework towers where the bridge trusses, 293½ ft. long without the cantilever arms, were assembled on the ground. The span weighed about 210,000 lb. and was hoisted to a height of nearly 90 ft. by four sets of 30-in. four-sheave blocks rove with 2-in. manila rope. The span was held suspended a little above the required height while the tower was moved back to the required position, and then was lowered to a permanent bearing on it and on the single bent at the opposite end, after which the projecting ends of the trusses were built out by the cantilever method.

The falsework tower used at the tower end of the bridge was designed to clear the permanent steel tower; it was made, as shown in the elevation, with two vertical bents 121 ft. high and 20 ft. apart, braced together by horizontal and diagonal struts at the top, above the highest position of the truss, and by four sets of lower horizontal struts, which could be removed from the inner vertical post to clear the truss when it was hoisted. Each bent consisted of two 8x10-in. vertical posts and two 10x10-in. inclined posts, made in 26 to 32-ft. lengths with butt joints and wooden scab splices, thoroughly bolted. The vertical and inclined posts were braced together by 4x8-in. horizontal and zigzag pieces bolted on, and the tower was guyed by twelve ¾-in. wire ropes attached to the vertical posts at the extremities of the horizontal struts.

The tower at the opposite end consisted of two vertical bents 122 ft. high and 5 ft. apart on cen-



Tower and Bent for Erecting Unloading Bridge.



Views of the Erection Towers at the Ends of a Gantry Bridge, at the Lackawanna Steel Works.

ters, between which the permanent steel bent was erected. Each falsework bent had two 8x10-in. outside batter posts and two 10x10-in. inside vertical posts, with splices and bracing similar to those of the other tower. The posts were seated on sills having a 10x12-in. center piece and pairs of 6x12-in. end pieces, and were connected at the upper end by a truss 11 ft. deep with a 10x12-in. bottom chord and a 10x16-in. top chord supporting pairs of 8x16-in. longitudinal jigger beams from which the hoisting tackles were suspended. The two bents were braced together by twelve sets of 6x8-in. horizontal longitudinal timbers bolted to the vertical posts, and were guyed by eight ¾-in. wire guys in the plane of the gantry truss and two similar guys in the plane of the tower bents.

The steel gantry was designed by the Wellman-Seaver-Morgan Co., and built and erected by the American Bridge Co., Mr. H. F. Lofland, manager.

Derivation of Constants for Building Losses.

A paper read before the American Society of Heating and Ventilating Engineers, by Prof. R. C. Carpenter.

I am very glad to see progress within the last few years in the use of scientific formulas for designing heating and ventilating apparatus, and this progress has been greatly aided by various scientific papers, read before this society. In a few years I believe the "rule of thumb" at present in use to a considerable extent will drop out of use entirely and be replaced by rational scientific methods. I believe that engineers in our work now generally recognize the fact that practically all phenomena relating to the transfer of heat fall under general laws of nature which can be expressed by rational formulas. It is also recognized that in the application of such laws or formulas "coefficients" connecting the theoretical with the practical case are necessary and must be applied. This paper deals with the origin of such coefficients as are applied to determine the transfer of heat through walls and windows of buildings.

In the calculation of radiating surfaces and the various elements of our heating systems we employ certain constants. It is a matter of very great interest to ascertain how those constants were found and whether they rest on a scientific basis of measurement or merely depend upon the estimate of designers, in which case they frequently vary greatly from the truth. The above statement might indicate that I was able to give you definite information as to the origin of many of these constants. I am sorry to state, however, that such is not the case. My object in presenting the paper is merely to call attention to the actual state of our knowledge, hoping that it will bring out, at later meetings if not in this one, the information desired.

At the August meeting of the Society, Walter Jones, of Stourbridge, England, read a valuable paper entitled "Heat Losses and Heat Transmission," in which he compared the different coefficients for building losses as given by various authorities. This comparison indicated that the authorities differed greatly as to some coefficients but were in quite close agreement as to others.

Some years ago I tried to find what actual experiments had been made for determining these various coefficients. The result of this investigation indicated that practically all of our coefficients for heat losses and heat transmissions resulted from experiments made by Peclet in France, about 1880, and further, that so far as I could ascertain these were the only original experiments which completely cover the field. These experiments are described in Vol. I, "Traite de la Chaleur," E. Peclet, Paris (1st ed., 1863, 4th edition, 1878.) I have published in the fourth edition of my work on "Heating and Ventilating," a translation of that portion of Peclet which relates to heat transmission through radiators and buildings. There is not available a translation of Peclet in English. Various authorities in different languages, in applying Peclet's experimental values to different conditions, have obtained slightly different results, partly due to difference in assumed conditions and partly due to the translation, and this in a large measure accounts for the difference in the various coefficients as given by different authorities.

There is no doubt that in some cases coefficients had been deduced from rules of practice or rules of thumb, but such coefficients have not generally been of a scientific form nor have they been widely used.

In the English work on "Heat," by Box, numerous examples of the application of Peclet's coefficients were given. This work was published very early, it was the first English work to call attention to Peclet's experiments, and is in a measure largely responsible for the coefficients which are used extensively by the English speaking people.

Box and Peclet both present methods of computing building losses by applying the coefficients to small sections of the building. This method is an accurate one, but it seems to me, in view of the crudeness of the coefficients themselves, a refinement which is not warranted except for very large buildings. For that reason I advise the use of average values in computing the heat losses from walls and windows of buildings of ordinary or small size. My own opinion is that the average values, which can be readily and quickly applied, give fully as satisfactory results as the application of each special coefficient to each special part of the building, and it saves a great amount of labor. For large buildings the more exact method is preferable, as suggested by Box and Peclet.

From my study of the Peclet experiments, which I believe are the scientific basis of the coefficients practically used by all our authorities, I do not believe that they have such a degree of accuracy as to warrant extending our computation results very far. To illustrate, if the Peclet experiments involve an error of 10 per cent., which I think probable, and if these determine our coefficients, it is rather absurd and foolish to carry out calculations in applying these coefficients to ½ of 1 per cent.; yet this is a thing which all of us are very prone to do and we often imagine that because our figures are carried to small decimal places, our results are therefore very accurate.

The coefficients which are given by Recknagel and Rietschel agree so closely with those derived from Peclet's experiments, that I believe they have the same origin as those which we have obtained from Box, which we know came from Peclet. This fact confirms me in the opinion that the scientific derivation of the principal coefficients used for heat losses from buildings is derived from Peclet's experiments.

Respecting the coefficients for heat transmission on radiating surfaces, a large number of experiments have been made in nearly every country. The coefficients derived from these experiments, however, agree so closely with those given by Peclet that for general cases those given by Peclet can be used with satisfactory results.

In view of the recent improvements in apparatus for measuring heat transfers and of the changes in building construction which have occurred during the last quarter century, it would certainly be desirable if the experiments made by Peclet could be repeated on a larger scale and with more accurate instruments. It is not probable, however, that if this were done the results would be essentially different from those obtained years ago by Peclet. We know that within certain practical limits Peclet's results are accurate, since the coefficients obtained from them when applied to modern heating systems give satisfactory results. In two cases I have had an opportunity of comparing the heat transmitted through the walls and windows of a building with the average of Peclet's results, and in both these cases the comparison checked up very closely.

In the first case a room on the second floor with exposed side and end had 246 sq. ft. of wall surface and 96 sq. ft. of window surface. By experiment I found that when the air in the room was 28° above that outside, 4,247 B. t. u. per hour were required to maintain a uniform temperature and represented the building losses; when 27° above, 4,240 B. t. u. were required. The average of Peclet's results indicate that 4 sq. ft. of wall surface or 1 sq. ft. of window surface transmits practically 1 B. t. u. per square foot per hour per degree difference of temperature. Applying this rule to the cases stated, the building loss for the first case should have been 4,410 and for the second case 4,253 B. t. u.

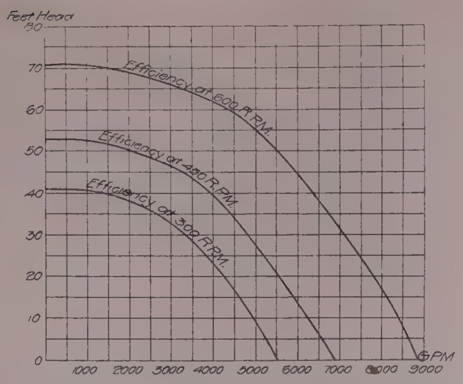
In the second case a test of the New York State Veterinary College showed that to maintain the building 31° warmer than the outside air, 16,000 B. t. u. were required per minute, of which 39 per cent. escaped in the ventilation flues and 61 per cent. passed by conduction through the walls and windows. The building was exposed on all sides, was three stories in height, had 9,280 sq. ft. of glass and 31,644 sq. ft. of exposed wall surface. By the rule founded on Peclet's average results as above, the building loss should be 532,952 B. t. u. per hour. The actual loss by experiment by the building was 547,200 B. t. u. per hour, which is within 2 per cent. of that called for by the rule. In this case the building was of brick, thickness of walls 24 to 16 in., the windows having single glass.

The above experiments, as well as those which are made by structures proportioned in accordance with the coefficients, indicate the substantial practical accuracy of the early experiments by Peclet, and show that we do not run any very great risk of making serious mistakes in applying them. It is quite probable that the variation in conditions as to materials or exposure, which are not considered in the average case, cause most of the errors in the application of these coefficients.

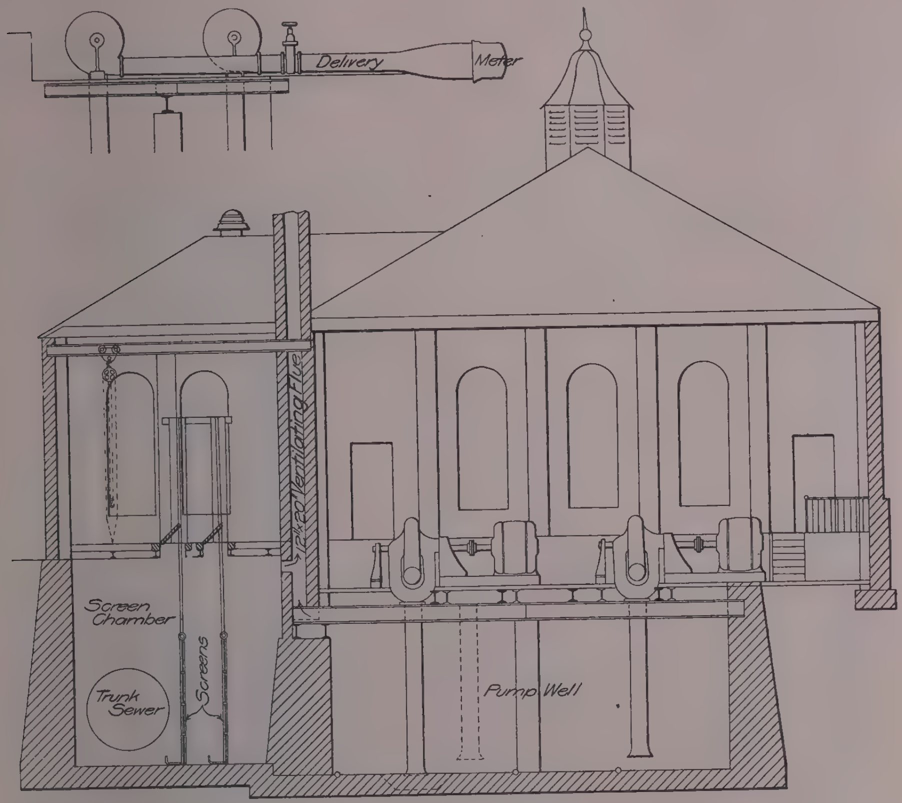
A Floating Derrick for handling rip-rap has been constructed by the government for the removal of the heavy rip-rap in the canal at Superior Entry, Wis., on Lake Superior, made necessary by the work of enlargement of the canal now under way. This work can be carried on only in the winter months when the waters are not muddy and opaque, and this necessitated a derrick of special construction to withstand the ice conditions. The plant consists of a 102x32-ft. deck scow of unusually heavy construction, which carries near the center a revolving steam derrick. The derrick is an A-frame with 40-ft. boom operand by a 30-h.-p. hoisting engine, which are carried on a circular platform revolving on a center bearing and circular railway of 20 ft. diameter, the platform being heavily counterweighted and also securely tied to the center bearing. A seven-tooth grapple operating on the "orange-peel" principle is used for raising the large blocks and boulders which range from 1 to 10 tons in weight, while for handling small boulders and rock, a five-tooth "orange-peel" grapple is used which has wide teeth forming a tight scoop when closed. The derrick is operated in water from 5 to 20 ft. deep through which the rip-rap may be clearly seen, and under ordinary working conditions, from 40 to 60 tons of rock may be lifted per hour.

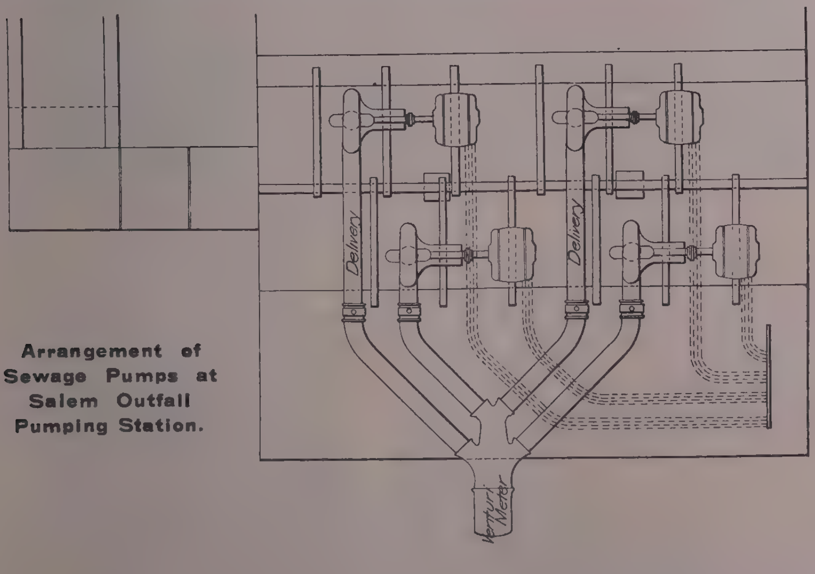
New Electrically-Driven Sewage Pumping Plant at Salem, Mass.

In 1900 a Commission was appointed by the City Council of Salem, Mass., to report upon improved means for disposing of the sewage of the municipality, there having been previously no well organized plan to this end. According to the old regime, the adjoining town of Peabody allowed its sewage to be carried away by the North River, running through the heart of Salem, while the latter city discharged its sewage into the same stream and into the bay at the mouth of the river. After engineering advice had been obtained it was decided to build an intercepting sewer from the Peabody line in a general way following the line of the North River to connect with a new main trunk sewer extending to a new pumping station on the west shore of Cat Cove. From the pumping station is was planned to build an outfall sewer or force main across Juniper Cove and the harbor bottom to an outlet near Great Haste Island, a distance of 9,915 ft. The work has just been completed, the consulting engineer for the system as a whole being Mr. Ernest W. Bowditch, of Boston. The engineer in charge of the work was Mr. W. P. Bates. The pumping station was designed by Major J. E. Spencer, chairman of the Salem Sewerage Commission.



Salem Pump. Performance Curves.





Arrangement of Sewage Pumps at Salem Outfall Pumping Station.

The work was divided into eight sections, the lengths, material and actual cost of construction being as follows: Force main, including pipe, 9,915 ft., mainly 30-in. cast iron, $143,497.64; pumping station and machinery, 500 h.-p., $38,000; main trunk sewer, estimated, final bills not yet in, 2,125 ft., 72-in. brickwork, $57,704.67; Section 1, 1,585 ft. 60-in. cast-iron pipe, $18,567.37; Section 1, 470 ft. 60-in. reinforced brickwork, $13,894.81; Section 2, 1,763 ft. 60-in. reinforced brickwork, $31,547.92; Section 3, 1,997 ft. 60-in. reinforced concrete, $16,538.84; Section 4, 2,134 ft. 57-ft. reinforced concrete, $19,528.84; Section 5, 2,686 ft. 57-in. and 52-in. reinforced concrete, $28,989.63; Section 6, 2,190 ft. 52-in. reinforced concrete, $24,932.79; total, excluding engineering and incidentals, $393,202.51.

A number of unique features characterize the new system. The outfall is probably the longest on the Atlantic Coast. The use of reinforced concrete in the sewer construction was attended with marked economy of cost, and the pumping station itself is completely electrical in its operating features. Gravity was insufficient to create a flow from Salem to the outfall, as the city is practically at sea level. The outfall sewer was laid 3 ft. below the bottom of the harbor in a trench to protect it from the anchors of vessels, and the requirements demanded blasting near the bottom of the main ship channel nearly 40 ft. below low tide to meet the desires of the War Department. The pipe was laid in 12-ton sections of seven or eight lengths (84 to 96 ft.) in order that all joints possible should be run with lead and caulked before immersion, leaving little of the critical portion of the work to be done by the driver.

Where reinforced brickwork was used, the wearing surface and a portion of the mass of the sewer at least 4 in. thick is of brick, the wearing surface in turn being supported by concrete, either on all sides, or only on the bottom and haunches. Two rings of brick were frequently used on the crown of the arch. The reinforced concrete construction included the use of No. 6 galvanized steel wire woven to a mesh of 6 x 12 in., and with welded contacts. The interior surface is much smoother in these sections than in the brick sections. The cast-iron pipe portion of Section 1 was used in crossing Collins Cove, and in a large part of Section 6 the foundations were so poor that it was found necessary to support the structure of the sewer on a false bottom. Spruce piles 25 ft. long were driven here and a plank flow built on top of the piles.

The contractors for the work were: Outfall, main trunk sewer and Section 2, Patrick McGovern, Boston; Section 2, T. H. Gill & Co., Boston; Sections 3 and 4, Pitman & Brown Co., Salem, E. H. Porter & Co., sub-contractors; Section 5, M. McDonough, Swampscott, Mass.; Section 6, built by day labor. This last section was constructed by day labor for the purpose of experiment, and the cost was about $3,000 in excess of the lowest bid. The pumping station was built by Pitman & Brown, and the pumping plant installed by Paul B. Patten, Salem. An emergency overflow was built in the main trunk sewer near the Philadelphia & Reading pier, for use in case repairs are needed at the pumping station or beyond. The contractor was R. H. Danforth, of Salem.

The 72-in. main trunk sewer terminates at the pumping station in a shallow well, dropping but 1 ft. below mean low tide level. The pumping station is a brick building with concrete substructure, floors and pump well; the interior is divided into a main pumproom 40 x 30 ft., an office, heater room and a screen room.

In order to scour the pipes, the pumps are obliged to have capacity enough to force the discharge through them at the rate of 6 ft. per second, or 19,000,000 gal. per 24 hours. This duty, however, is demanded for but 2 hours per day, and at present the ordinary flow is estimated at not over 6,000,000 gal. in 24 hours; so that the pumps are considerably underworked during the major portion of the time. There is 11 ft. difference between low and mean high water. The minimum heads vary from 7 to 8 ft. according to the height of the tide, and the maximum heads corresponding to the larger and more rapid discharge, vary from 49 to 60 ft.

Three motive powers for driving the pumps were considered by the Commission—the steam engine, the gas engine and the electric motor—although previous to June, 1904, all of the estimates on the pumping station had been made on the basis of using steam pumps. Realizing the permanence of the installation, careful attention was given to the merits of each type, on the basis of operating and maintenance expenses rather than first cost, with the result that the electrical equipment was adopted. Proposals were obtained from representative electric motor, steam and gas engine builders, the engineering requirements being the same in each case, viz.: to provide a unit or units having guaranteed duties of 6,000,000 gal. in 24 hours against a head of 18 ft.; of 12,000,000 gal. against 35 ft., and of 19,000,000 gal. against 60 ft.

The gas engine builders proposed a separate unit for each head on account of the limited speed range of this type of prime mover; but the first cost was so high that they submitted a plan following the suggestion of the induction motor drive, viz., the installation of four three-speed units, each of 6,333,000-gal. capacity. The plan provides for the combining of these units to give three duties: a duty of 6⅓ million gallons per 24 hours obtained by one unit running 300 r. p. m. and pumping against a head of 18 ft.; a duty of 12⅔ million gallons obtained by two units running at 450 r. p. m. against a head of 35 ft.; and a duty of 19 million gallons obtained by three units running at 600 r. p. m. against a head of 60 ft.; the fourth unit being a reserve.

The steam pump manufacturers proposed to obtain the required duty by installing two cross-compound units, each of 9,000,000 gal. capacity; obtaining the speed required for the lowest duty by operating one unit with one cylinder cut out, and the higher duties by using both cylinders and adjusting the cut off.

In comparing these methods, curves were prepared showing the horse-power necessary for each system, and estimates of the building cost and operating expense of each method were submitted. The first cost of the gas engine station was about twice that of the electric drive, while the steam plant was about three times as expensive. The floor space required by the gas engine station was about three times as great, and by the steam station, about five times as great as that needed by the electrical equipment. With coal at $4 per ton, gas at 75 cents per thousand feet, and electric power at 1¼ cents per horse-power-hour, it was estimated, taking all station expenses into account, and putting them on a 16-hr. basis, that it would cost $21,000 a year with steam, $15,000 with gas, and $14,000 with electricity. The electric drive had the further advantages of simplicity of operation in starting and running, freedom from danger of complete shut down for repairs, ease of handling the whole station from one point, the large number of combinations of units available, as all four induction motors were duplicates, any three being easily run at the time of maximum demand, noiselessness, cleanliness and minimum attendance.

The central station company, the Salem Electric Lighting Co., which supplies power for operating this plant felt justified in making the extremely low rate of 1¼ cents per horse-power-hour (1.67 cents per kilowatt-hour) on account of the desirability of the business; since it was stipulated that no power should be taken at the time of the peak load on the electric light plant, and that the maximum demand for power, for flushing the sewer, was to be made only at the time of the valley load.

The equipment as installed consists of four 14-in. Worthing horizontal volute centrifugal pumps, each direct connected to a General Electric, 2,080-volt, three-phase, 125-h.-p. induction motor wound for 300, 450 and 600 r. p. m. The capacity of each pump is 6⅓ million gallons per 24 hours against a total head of 60 ft. at 600 r. p. m.; 6⅓ million gallons against 35 ft. at 450 r. p. m., and the same volume against 18 ft. at 300 r. p. m. The suction pipes are 16 in. in diameter and the discharge pipes, 14 in. All four discharge pipes deliver into a 30-in. main through a pair of Y's, so that the bends in the piping are reduced to a minimum. The discharge piping is all exposed in the station, so that it can be easily examined or repaired, the motors and pumps being reached by a rubber matted platform. Full line voltage is used in the main motors and the suction side of each pump is provided with a special water seal to protect the bearing from the possibility of contamination with the liquids pumped. Cast-iron impellers are used in the pump.

At opposite ends of the pump room are installed two Knowles dry-air priming pumps, of the horizontal duplex type, cylinders 5 x 5 in., direct geared to a 5.5 h.-p., 900-r.p.m., General Electric induction motor wound for 110 volts, 60 cycles. Each motor is connected with two transformers for potential reduction. On each of the four discharge pipes is installed a 14-in. Chapman valve operated by a ½-h.-p., 1,200-r.p.m., 110-volt, General Electric induction motor. The valves can also be operated by hand if desired.

The switchboard and gauges are installed in one corner of the plant close together, and the entire installation is operated by three eight-hour shifts of one man each. Including priming, a pump can be placed in service in about 3 minutes. The switchboard consists of six panels, comprising one incoming line panel, four motor panels and one combination priming pump and lighting panel. Both Nernst and ordinary incandescent lamps are used on the station lighting circuits with recording wattmeters on each for comparison. The operating mechanism of the switchboard panels enables the entire station to be controlled from one place, with the exception of the motor-starting compensators, which are located on the wall at one side. A speed changing switch for a pump motor and a switch for controlling the corresponding main valve motors are located on each motor panel.

The priming system was devised by Mr. Spencer. All four priming pipes, from the main pumps, lead into a trunk pipe back of the switchboard, and the corresponding valves are located on the sub-base of the priming pump and lighting panel. The trunk pipe leads into a drum, out of the top of which the air is exhausted by either one of the dry-air pumps, two air-pump valve stems being brought to the switchboard, so that the valve of the idle pump may be closed. Water is prevented from being drawn over into the dry-air pump, through any chance neglect, by a ball float arrangement connected to a two-part balanced valve. Any water that may be drawn into the drum can be blown off by closing both the priming pump valves and opening a valve in the discharge pipe.

A performance test of one of the 125-h.-p. pumping units made at the factory is reproduced herewith.

Intermediate Span of Richland Creek Viaduct Supported on Incomplete Tower.

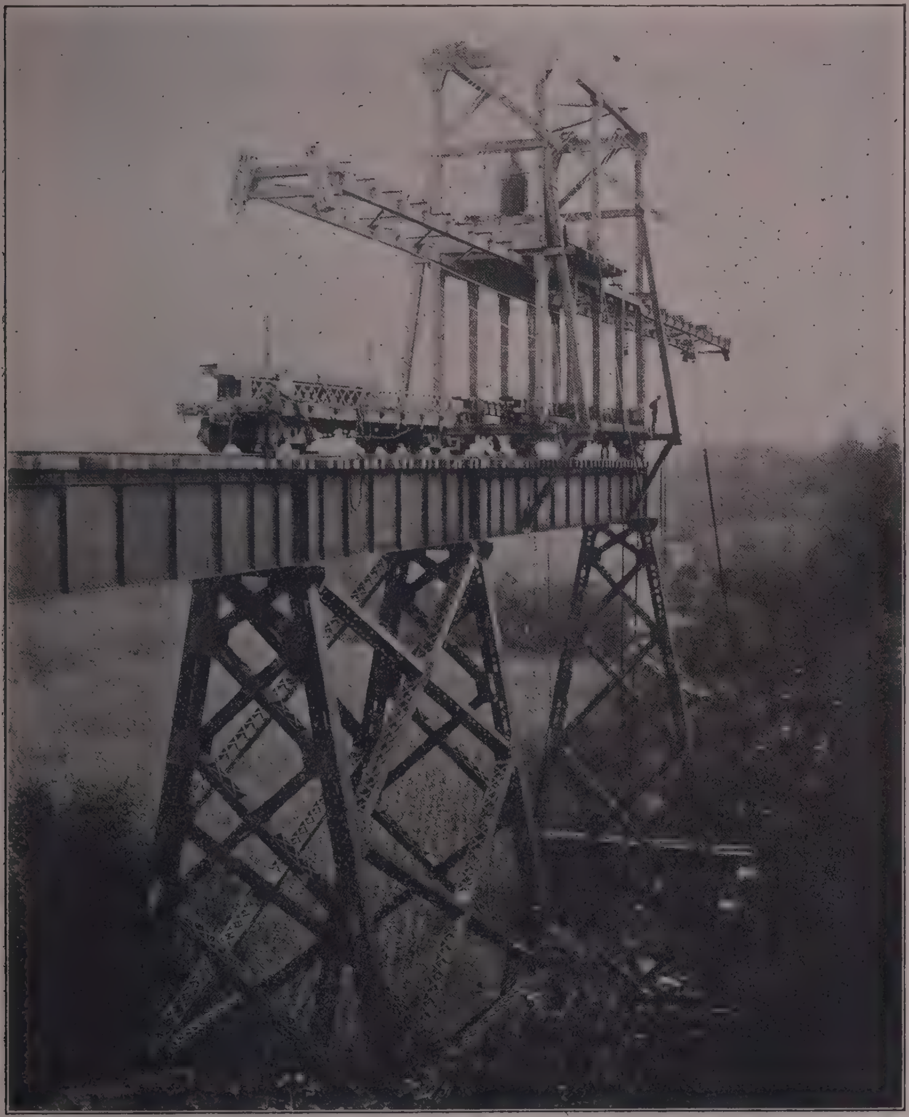
THE MEASUREMENT OF FROZEN STREAMS, one of the most perplexing problems that has confronted hydrographers, is the subject of Water Supply Paper 187, published by the United States Geological Survey. The data collected by the Survey regarding stream flow have been a great benefit in the development of water powers, but to be of conclusive value the estimates must cover the winter periods, when the water is likely to be lower than at any other season. In the northern and central parts of the United States, the streams are generally covered with ice for a considerable portion of the year, varying from nearly five months in the extreme North to a few weeks in the Central States. The methods of measuring open streams are fairly well defined, but the laws that govern the flow of rivers that are frozen have been but little investigated. The Geological Survey for several winters has made investigations on frozen streams in the New England States and in New York, and the ice conditions in the various streams are described in detail and general methods for this work are formulated in the paper referred to. It may be obtained from the Director of the Survey at Washington.

Three Large Concrete Bridges.

Three large concrete railroad bridges have been built across the River Iller, near Kempton in Southern Germany, to replace an old iron bridge. The three new bridges are exactly alike and are built parallel, two of them resting on common foundations, with only 4-in. clearance. This arrangement was adopted to reduce lateral stresses due to unsymmetrical loading. Each bridge carries a double track, is of the three-hinged type, and consists of three viaduct arches of 71-ft. span and a main arch over the river with a span of 211 ft. 6 in. and 100 ft. 6 in. headway above the mean water level. The grade of the tracks over the bridge is 1 per cent. The hinge joints of the main arch are made of large cast-steel blocks, while the joints for the secondary arches are formed of 5/16-in. rolled sheet-lead placed between the joint bed-stones. The main hinge-joints were placed in position, bolted together in order to avoid lateral displacement, and the joint splay was taken up by cork plates encased in thin zinc sheeting. The concrete for the main arch, which must withstand maximum stresses of 500 lb. per square inch, was made in the proportion of 1 part cement, 2½ parts sand, and 5 parts crushed dolomite rock; for the abutment piers, with a maximum stress of 370 lb. per square inch, 1:3:6 and the foundations 1:5:9. Breeze concrete in the proportion of 1:12 was used to fill out the arches. Special inspection chambers were built to enable the hinge joints of the main arches to be observed.

The Erection of the Richland Creek Viaduct, Indianapolis Southern R. R.

The Indianapolis Southern R. R., a branch of the Illinois Central system, crosses Richland Creek, 7 miles from Bloomfield, Ind., at a height of 158 ft. above the water on a single-track plate girder viaduct about 2,215 ft. long. The substructure is of concrete with separate pedestals for the feet of the tower columns; the superstructure consists of 40-ft. towers carrying 40-ft. tower spans and 75-ft. connecting spans of plate girders of a uniform depth of 7 ft. and weighs altogether about 3,000 tons.



Traveler Erecting the Second Bent of Tower.

Each of the eighteen towers has two transverse bents 40 ft. apart on centers, each having two columns 8 ft. apart at the top and battered 2¼:12, giving them a bottom width of 27 ft. 4⅛ in. for the maximum height of 124½ ft., which occurs at seven towers in the center of the viaduct. At the ends of the viaduct, the height of the towers diminishes to 28½ ft. for the shortest bent, many of them having bents toward the end of the viaduct considerably shorter than those toward the center. The towers are without horizontal struts except at the base, and are X-braced on all four sides with diagonals made of pairs of 10-in. 20-lb. channels. The bottom longitudinal transverse struts are sometimes horizontal and sometimes inclined to correspond with the different elevations of the column feet, and in all of the taller bents have their center points supported from the intersection of the lower panel of knee-braces by a vertical suspender made of four 3½x3-in. angles. The plate-girder spans rest directly on the column tops and are provided with an expansion joint at one end of each 75-ft. span.

Erection was commenced Sept. 10, 1906, and the superstructure has been assembled by a special traveler shown in the accompanying pictures. This consisted of a three-bent vertical wooden tower about 50 ft. high and 180 ft. long, which supported a pair of horizontal wooden girders about 180 ft. long over all with a clearance of about 25 ft. above the track. The girders were braced together with horizontal struts and diagonal rods, virtually forming a Howe truss, and projected beyond the front and rear of the traveler to provide cantilever arms for unloading and assembling the steel. The front arm had an overhang of about 80 ft., and both it and the rear arm were supported by steel rope backstays to the top of the tower. Each girder was provided with a track on which a pair of trolley hoists moved from end to end. These hoists lifted the viaduct members from the flat cars by which they were delivered on top of the completed structure, carried them through the traveler, and lowered them to position from the overhang.

The four tackles suspended from the trolleys were operated by a hoisting engine built by the Monighan Machine Works, Chicago, and carried on a platform in the tower above the trolley tracks. The lengths of the overhang were sufficient to command two cars in the rear of the traveler and to reach beyond the finished structure far enough to assemble the first bent of the next tower in advance. This was guyed in position, until the forward ends of the next 75-ft. girder spans were seated on it and connected, making a stable construction on which the traveler advanced to build the second bent of the tower and set the 40-ft. span, moving out on it and repeating the operations.

The transverse sills of the tower extended outside the planes of the girders and were braced to the upper part of the vertical posts by battered legs, increasing its transverse rigidity, while X-bracing in the upper parts of the transverse bents prevented distortion there. When in service the extremities of the transverse sills were braced from the feet of the batter posts to the lower flanges of the plate girders by temporary wooden struts securely wedged in position, and the tower was anchored to the top of the viaduct. The heaviest pieces handled by it were the 20-ton 75-ft. girders.

The viaduct was erected in 50 days by an average force of 40 men. Field rivets were driven by ten Boyer pneumatic hammers operated by compressed air from an Ingersoll-Rand machine driven by a 25-h.-p. Columbus gasoline engine. Each hammer drove an average of 300 rivets a day, the record being 525 rivets for one gang. Material was delivered by the railroad seven miles from the bridge site, where it was stored and loaded by a derrick car on flat cars which were drawn to the site as required by a construction locomotive.

The bridge was designed and constructed under the direction of Mr. R. E. Gaut, bridge engineer of the Illinois Central Railroad Co. The steel work was fabricated at the Detroit plant of the American Bridge Co., and was erected by the Strobel Steel Construction Co., Chicago, Mr. J. E. Baggs, superintendent.

An Electric Train on the New York Central road was wrecked on the evening of Feb. 16. It consisted of two electric locomotives and five passenger coaches. In rounding a curve the rear cars left the track and were dragged along on their sides, killing and wounding many passengers. Although several explanations of the accihave been advanced, none is satisfactory.

Strength of Brick and Brick Piers.

Paper presented by James E. Howard at the convention of the National Brick Manufacturers' Association, at St. Louis, Feb. 7.

The results of tests of brick and brick piers which I have the honor to present are selected from those which have been made in the testing laboratory at the Watertown Arsenal. In this laboratory various kinds of constructive materials are tested, the results of which are published annually by the Ordnance Department, U. S. Army, in reports entitled "Tests of Metals and Other Materials for Industrial Purposes," Congressional documents for public distribution. Twenty-five volumes have thus far been published. From these reports and from current tests, which will appear in subsequent volumes, certain results have been brought together, results which are thought to be representative of their respective kinds of material, as qualified by the explanatory remarks relating to them.

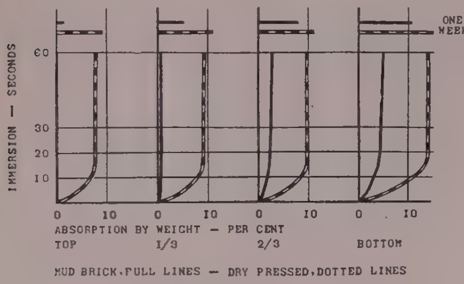


Fig. 1. Absorption by Brick.

Bricks are possessed of those physical properties which are common to other materials of construction. That is, they have strength to sustain loads, elastic properties whereby their dimensions are slightly changed during the period of loading, springing back to their original shapes, or nearly so, when the loads are removed; they expand and contract with changes of temperature, and it appears that their volumes are slightly affected when saturated with water, swelling minutely but perceptibly when wet. Properties inherent in individual bricks are reproduced in piers constructed therefrom, modified, however, by the properties of the mortar in which the bricks are laid, and mortars vary according to their composition and age. In general, the properties of constructive materials are found to present many variable elements, some of which are under control and some are not.

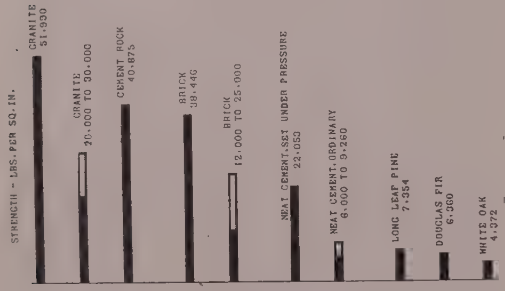


Fig. 5. High Compressive Strengths.

Passing at once to the subject of individual brick, values for the coefficient of expansion by heat have been observed over a range from 0.0000020 to 0.0000074 per unit of length per degree Fahrenheit. An ordinary value would be in the vicinity of 30 to 40 ten-millionths, that is, somewhat less than steel, which has a value a little above 0.0000060.

In making these determinations the brick were heated in water baths, basing the value of the coefficients upon the contractions displayed in passing from the bath of boiling water to one at about freezing temperature. It was necessary to use the measurements taken on falling temperatures to eliminate the effect of the swelling of the brick due to absorption of water.

The brick usually swelled and were longer on the gauged lengths when in water at 33° Fahr. than originally, when dry and in the air at 68°. Moreover, after having been through the hot water bath and returned to the cold one, their lengths were found still further increased.

When a brick saturated with water is frozen, it expands, due to the action of the water within. The amount of such expansion, in going from 33° down to, say, 25°, measured on a length of 6 in., has been found to range from a few ten-thousandths of an inch to above one-half a hundredth of an inch. Not infrequently, freezing a brick saturated with water is attended with a permanent increase in its length.

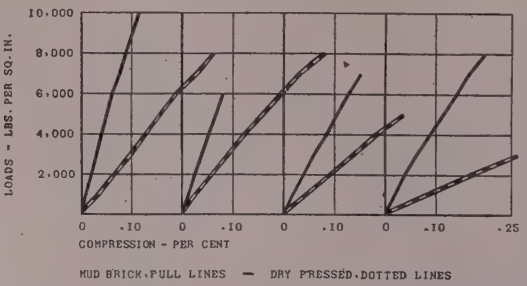


Fig. 2. Brick from Different Parts of Kiln.

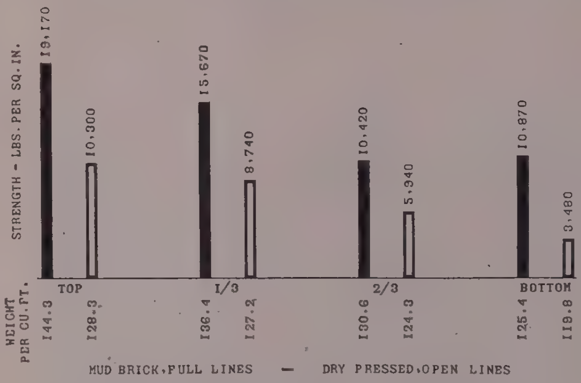


Fig. 3. Brick from Different Parts of Kiln.

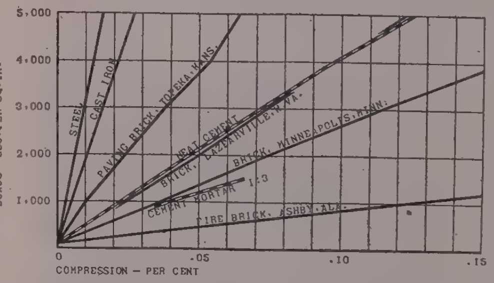


Fig. 6. Stress-Strain Curves.

The elastic properties of brick have been observed, measuring the compressibility of the material as loads are applied and determining the permanent sets, when such have been acquired. Light, hard and salmon brick are most compressible, hard burnt and vitrified brick least compressible.

The moduli of elasticity, deducting the permanent sets in computing these values, range from less than 1,000,000 to a maximum of 10,000,000 lb. per square inch. Permanent sets, when they occur, are usually of small magnitude. From this it follows that the curves of compressibility are nearly straight lines; that is, in individual cases the amount of compression of a brick is nearly proportional to the load which is placed upon it.

The compression of the brick, in the direction in which the load is applied, is accompanied by an expansion in a lateral direction, which, as well as the direct compression, is a measureable quantity. The usual ratio of lateral expansion to longitudinal compression falls between the limits of one-fifth and one-tenth.

Density of structure is shown by the amount of water which a brick will absorb. Usually the absorption is reported in percentage by weight. A better method seems to be to judge of the voids by the volume of water absorbed. Water enters a porous brick very promptly, less rapidly in the harder ones, but complete saturation is not accomplished even at the end of a week's immersion. Additional water is absorbed by exposure in a bath of hot water.

The compressive strength of brick extends over a wide range in values. The weight per cubic foot of the material, its density of structure, modulus of elasticity and compressive strength are mutually dependent features, and all are influenced more or less by the conditions of manufacture. The records of tests on compressive strength are numerous and generally available to all. "Reports of Tests of Metals," 1894, and following years, contain many such results. Nearly 500 State, Territorial and other libraries are designated depositories for Congressional documents, where these volumes may be examined by those who do not have them personally.

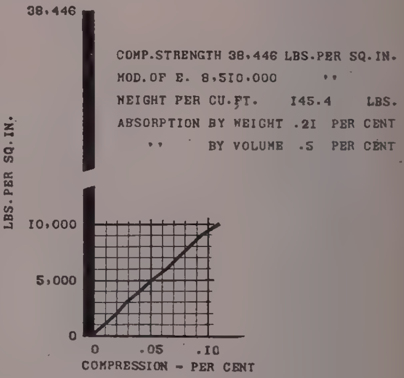


Fig. 4. An Abnormal Brick.

Fig. 1 shows the rate of absorption of some dry pressed and mud brick, which were burned side by side in a down-draft kiln. The mud brick are shown by full lines, the dry pressed by dotted ones. These samples were weighed at frequent intervals during the early stages of immersion. It appears that a considerable part of the water eventually absorbed entered some of the samples during the first fifteen seconds of immersion. After this time absorption went on slowly. The upper horizontal lines indicate the amounts which were absorbed at the expiration of a week's time. The lesser amounts of water absorbed by the brick from the top of the kiln over those farther down will be noted.

In Fig. 2 are shown the stress-strain curves of the samples of Fig. 1. The greatest degree of rigidity is displayed by those from the top of the kiln, becoming more compressible as they are taken from the lower parts. The order in which these curves are plotted is the same as in Fig. 1, with reference to their position in the kiln. It will be noticed that the mud bricks from the bottom of the kiln displayed as much compressibility under a load of 4,000 lb. as the corresponding brick from the top displayed under twice the load.

The variation in compressive strength is equally pronounced, according to position in the kiln, as shown by Fig. 3. The weights per cubic foot of the material are entered along the lower edge of the diagram. The highest strength corresponds with the greatest weight. This is characteristic, also, of other materials of construction, high resistance and high density of structure being found in the same samples.

The properties of a remarkable brick are shown in Fig. 4. So phenomenal was its compressive strength that it is fully deserving of a special diagram of its own. To St. Louis belongs the honor of producing this brick, which far exceeded in strength any brick heretofore tested at Watertown Arsenal. This sample was tested on end, and reached a total load of 376,000 lb. on a surface 2.45 x 3.99 in. in cross-section.

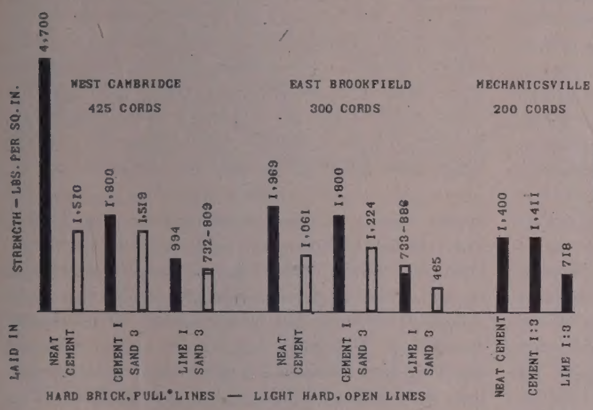


Fig. 7. Strength of Birch Piers.

The Laboratory records were gone over, and from them were selected the results which appear in Fig. 5. These tests represent the highest of their respective classes. They are what have been attained, and are presented as standards of excellence. The granite of 51,990 lb. per square inch compressive strength came from a quarry in Asheville, N. C. Ordinarily granites range from 20,000 to 30,000 lb. per square inch. The cement rock represents the stone from which a natural cement is obtained, from the State of New York. The brick of 38,446 lb. strength has just been described. Ordinary values for hard burnt brick range from 12,000 to 25,000 lb. per square inch.

Portland cement, set under pressure, attained the maximum strength yet observed in this material. This sample was exposed to an initial pressure of 14,000 lb. per square inch while setting. The strength given in the diagram was displayed by the cement at the age of 57 days. The strength of ordinary Portland cement, tested neat, ranges from 6,000 to 9,260 lb. per square inch.

The strength of the white oak stick seems low taken in comparison with the strength of the long leaf pine and the Douglas fir wood. In small pieces white oak has shown a compressive strength of 9,000 lb. per square inch. The figures here given refer to a post of commercial size.

The stress-strain curves of several representative materials are shown in Fig. 6. Steel and cast iron are here plotted for reference purposes. A paving brick from Topeka, Kan., occupies a position next to the cast iron and steel. Then follow the curves of neat Portland cement, a brick from Lazearville, W. Va., then a brick from Minneapolis, Minn., and the curve of a cement mortar of one part Portland cement and three parts sand, and at the lower part of the diagram appears the curve of a fire brick from Ashby, Ala. This diagram shows the range in compressibility which may be met with ordinarily. The number of curves might be extended, but other grades of material would occupy places between the curves of the paving brick and the fire brick.

Fig. 7 shows the results with piers made of hard and light-hard sand struck brick laid in different kinds of mortar. Brick from three yards are represented, the amount of fuel used being 425 cords, 300 cords and 200 cords, respectively, per million brick. One grade only was received from the yard where the smallest quantity of fuel was used, which was classified as hard.

The range in strength from the hardest brick laid in neat cement, to the weakest light-hard brick laid in lime mortar is seen to be very great. In respect to the compressibility of the piers under loads, the difference is greater than shown by their ultimate strengths. It is desirable to use neat cement or a strong mortar in laying hard brick in order to attain maximum strength and rigidity. Rigidity is regarded as an important factor in construction as well as strength.

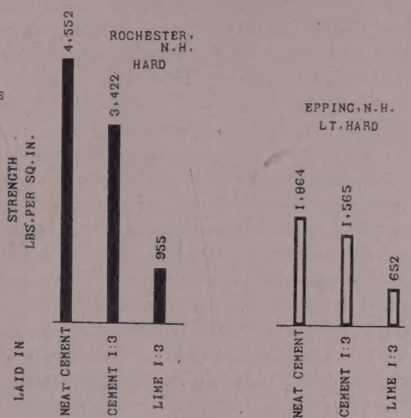


Fig. 8. Piers of Water Struck Brick.

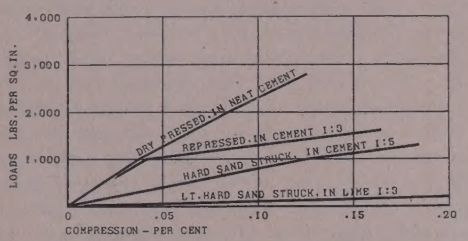


Fig. 9. Stress-Strain Curves, Brick Piers.

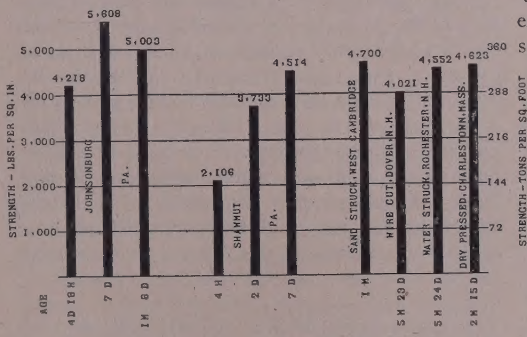


Fig. 10. Strong Brick Piers.

Lime mortar should not be used when either of the considerations just mentioned are essential.

Two values are shown for two of the piers. The brick from these yards were panelled on one side, and the higher strength in each of these piers belongs to duplicates in which the panels were filled with neat cement before laying.

Some results with piers made of water-struck brick are shown in Fig. 8. One yard furnished the hard, another the light-hard brick. The influence of the mortar on the ultimate strength of the pier is again well shown. It seems a wasteful effort to use a weak mortar in which to lay a pier of hard, strong brick.

The curves of compressibility of some piers are shown in Fig. 9. An earlier stress-strain diagram, Fig. 6, showed corresponding results on individual brick, and other materials. On the present diagram the most rigid condition pertained to the pier made of dry-pressed brick, laid in the neat cement. A pier of repressed mud brick appears next in the order of relative rigidity, then a hard-sand struck brick pier laid in less rich mortar than used for the repressed brick, and most compressible of the group is the pier of light-hard brick which was laid in lime mortar. The characteristics of these piers depend chiefly upon the quality of the mortar employed.

From this exhibit it may be seen how unfavorable is the action in a wall, the face of which may be laid with one class of work while the backing is of another.

In order to illustrate the strength which may readily be attained in brick pier construction, the results of some strong piers have been brought together in Fig. 10. The four piers represented on the right are taken from earlier tests, the results of which are among the published records of the laboratory. The other six represent piers built and tested just prior to the time of this convention. These latter ones were intended to be strong piers, a result which was realized in the tests. They were about 8 ft. in height each, nominally 12 in. square; they had hollow cores, and the brick were laid on edge in neat cement.

The ages of the piers are entered along the lower edge of the diagram. One pier, the youngest of the series, was tested the day it was laid. The test began about one hour after the last brick was in place and was finished three hours later, or when the pier was four hours old. It developed a compressive strength of 2,106 lb. per square inch. The mortar had not hardened, and unusual compressibility was of course displayed. The total load on the pier reached 118 tons, a load far in excess of any which could be expected to be placed upon it in constructive work, at so early an age.

Horizontal lines represent pounds per square inch on the left of the diagram, and on the right side, tons per square foot. One pier reached a strength of 360 tons per square foot, another exceeded this load. The allowable load prescribed by the building laws of some cities is understood to range from 15 to 30 tons per square foot, which seems a very low limit in the presence of piers possessing the ultimate strength these displayed.

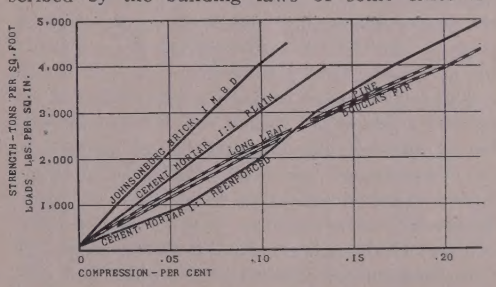


Fig. 11. Stress-Strain Curves, Piers.

The stress-strain curves of one brick pier, two mortar columns and two wooden posts are shown in Fig. 11. These curves stand for strong examples of their respective kinds. These illustrations and others which have gone before were selected, in many of the cases, to indicate what seems best in constructive materials, examples which could safely be followed where strong and safe construction is needed.

The Colorado River was again confined to its banks on Feb. 11, when the last break was closed. Levees are now being put in good condition along the river and it is hoped that the Imperial valley is at last saved from the inundation which threatened it a number of times. The main facts in connection with the long series of breaks in the river banks and the formation of the Salton Sea were stated so recently in this journal that it is unnecessary to repeat them here. Mr. Cory and his staff have worked long and arduously at this task, which has been one of the most unusual engineering problems in the country.

Cost of Hauling Crops by Wagon from Farms to Shipping Points.

At an early date the United States Department of Agriculture will issue a report on the cost of hauling crops from farms to shipping points. The figures given are based upon returns from nearly 1,900 counties and cover practically the entire farming area of the country.

The average cost to the farmer of hauling wheat from farms to shipping points is given as 9 cents per 100 lb., the average distance hauled is 9.4 miles, and the average wagon load of wheat weighs 3,323 lb., thus containing about 55 bushels. For cotton, the average load is 1,702 lb., distance from shipping point 11.8 miles, and cost of hauling 16 cents per 100 lbs. Reduced to terms of cost per ton per mile, the rate for wheat is 19 cents, and for cotton 27 cents.

The highest cost of haul is for wool, which is carried on an average 39.8 miles from farm or ranch to shipping point at a rate of 44 cents per 100 lb. for the entire distance. The lowest cost for any one product is for hemp, which is hauled from farms to shipping points at an average cost of 6 cents per 100 lb., the average distance hauled being 5.2 miles and the average load of hemp weighing 3,393. lb.

For the entire distance from farm to shipping point corn, oats, and barley are each hauled at an average cost of 7 cents per 100 lb.; hay, flaxseed, rye and timothy seed, 8 cents; wheat, potatoes and beans, 9 cents; tobacco and live hogs, 10 cents; rice, hops and buckwheat, 11 cents; apples and peanuts, 12 cents; vegetables (other than potatoes) and cotton seed, 15 cents; cotton and fruit (other than apples), 16 cents; and wool, 44 cents.

Except in the case of wool, practically all costs represent the expense incurred by farmers in hauling their own produce. Wool is hauled in the Rocky Mountains largely by regular freight wagons, and the wool growers pay for the hauling at varying rates per 100 lb.

The total tonnage of farm products hauled on country roads in the United States is not known, but of twelve leading products it is estimated that nearly 50,000,000 tons were hauled from farms during the crop year 1905-6, at a cost of about $85,000,000, or more than 5 per cent. of their value at local markets. Of this traffic, 40,000,000 tons represent the weight of corn, wheat and cotton, and the cost of hauling these three products was $70,000,000.

The number of working days taken to haul twelve leading crops from farms to shipping points during the crop year 1905-6 is estimated as 21,417,500, and the number of loads taken as 30,319,000. The greatest time for any one crop, in hauling to shipping points, is 8,494,200 days for corn; but if the time taken for hauling to local mills the wheat consumed in the counties where grown be included, the total number of working days taken for hauling wheat from farms during the crop year just mentioned would be over 8,900,000.

Although there were fewer loads of cotton than of oats, it required 1,000,000 more working days for men and teams to haul the fiber than this grain, the average time for a round trip for hauling oats being 0.6 day and for cotton 1 day.

Including wheat hauled to local mills for grinding, the total number of wagon loads of the twelve crops just referred to was 34,200,000, and the services of men and teams for 24,500,000 working days were used in moving these loads.

The greatest distance over which it will pay to haul a given crop will practically limit the production of that crop for the market. Beyond that limit, a more valuable product must be made. Cotton is hauled a greater distance than wheat, and wool is hauled on an average more than four times as far as wheat and more than three times as far as cotton. Live animals are often profitable substitutes for crops on land remote from shipping points, for the animals may be driven at an expense far less than the cost of wagon transportation.

The distance limit of profitable farming for a given crop may often be extended by improving methods and means of hauling. Better wagons and horses may be used, roads may be improved, and better facilities may be had for receiving the products at local markets and shipping points. Improvements of this kind tend to lessen the expense of hauling a load, and thus make it profitable for farmers to haul from greater distances. Average loads for the same product weigh in some States twice as much as in others, and consequently the expense of hauling is much less in the former States than in the latter for similar distances.

The average distances from farm to shipping point for twenty-one of the twenty-three products treated in this report range from 7 to 12 miles. The average distance over which hemp is hauled is 5.2 miles; oats are hauled an average of 7.3 miles; corn, 7.4; rice, 7.5; live hogs, 7.9; timothy seed, 8; peanuts, 8.1; potatoes and buckwheat, 8.2; hay, 8.3; rye, 8.4; barley, 8.8; beans, 9; wheat, 9.4; apples, 9.6; tobacco and vegetables (other than potatoes), 9.8; flaxseed, 10.4; cotton seed, 10.7; fruit (other than apples), 11.6; hops, 11.7; cotton, 11.8; and wool, 39.8 miles.

The most remote farms from which a certain product is hauled in small quantities may be easily several days' haul from a shipping point; but the product hauled, unless itself valuable, must usually be taken on the same load with goods of relatively high price. A few bags of corn or potatoes may be hauled 60 or 70 miles over mountainous roads to a local market and sold without loss to the producer if the same wagon carries also a considerable quantity of poultry and dairy products. From one community in the Rocky Mountains, wheat and oats are hauled on wagons a distance of 100 miles, cotton is hauled from one county in the Southwest 110 miles to a shipping point, while one report from west of the Rocky Mountains gives 165 miles as the length of the longest wagon route over which wool is taken from shearing camps down to a railroad station.

A Large Steel Vault, recently built for the Royal Bank of Scotland, is said to be one of the strongest in existence. The wall, roof and floor consist of a series of 2-in. slabs of steel which are riveted and bolted together so as to make one continuous piece. Each slab weighs 1 to 2 tons and is made by riveting together by hydraulic pressure four plates of Cammell's alloy steel which offers a maximum resistance to drilling. The backing consists of layers of hard and mild steel plates welded together. The slabs are fastened together by the double tongue and groove method, which effectively conceals the joint, and on the outside a connecting bar is riveted to one slab, into which bolts, passing from the inside of the slab to be joined to it, are screwed. The floor is covered with pressed rubber tiles. The outer door plate is a slab of Harveyized armor plate 4½ in. thick and weighing 2½ tons, and it has been tested by firing a 6-in. naval gun propelling a 100-lb. nickel steel shell against it at a range of 50 yards. There are no spindle or key holes in the door. Twenty Chubb diagonal bolts are secured by a triple time lock, a keyless combination lock, and a special anti-explosive lock protected by a heavy manganese steel casing within the vault. The hinges are adjustable, and are mounted on ball bearings which enable the door to be moved with comparative each. The vault was built by Messrs. Chubb & Sons' Lock & Safe Co., London

Book Notes.

Prof. C. G. Wrentmore, of the University of Michigan, has prepared a volume of "Batter Tables," for 192 batters from 1/16 in. to 12 in. per foot, giving the altitude and hypothenuse in feet and decimals of a foot for any base measured in feet, inches and sixteenths; there is also a table of the equivalents of inches and fractions in decimals of a foot, printed on a flap inside the front cover so it can be kept in sight while the main table is in use. The author presents the volume as a supplement to tables of squares and logarithms. Draftsmen on steelwork will readily appreciate the help such a book may be. (New York, Eng. News Publishing Co., $5.)

The federal testing laboratory at the Zurich Polytechnic Institute is under the direction of Prof. T. Schüle, who has recently published a report of the elaborate investigations of reinforced concrete which he has been making. This report is entitled "Resultate der Untersuchung von armiertem Beton," and is printed in a quarto volume of 141 pages, with many illustrations. The experiments were made with specimens subjected to simple tension and also to bending, and special attention was paid to conditions during the removal of stress. The bending tests were made with beams of both square and T-section, and great care was taken to determine all the attendant conditions which might have influenced the results. The data are given in full, and there are excellent engravings of some of the beams which failed, so that the book is one of the most valuable contributions yet made to our knowledge of the subject. The conclusions drawn by Prof. Schüle from the tests are that ordinary formulas used in computing the strength of reinforced beams are needlessly complicated by factors representing conditions which apparently do not have any appreciable influence on this strength, and that provision must be made for resisting end shear to a greater extent than is now customary. (Zurich, E. Speidel.)

A book that will probably be found as useful in the drafting office as in the classroom is the small volume on "Machine Design," by Prof. Charles H. Benjamin. It takes up in turn the properties of materials used in machines and engines, the design of frames, cylinders and pipes, fastenings of all kinds, springs, sliding bearings, journals and bearings, ball and roller bearings, shafting and couplings, gears and pulleys, cranks, flywheels and transmission of power by belts and ropes. Although the book was prepared mainly as a text-book, it contains mainly what the author had found necessary in his own practice as an engineer. What the student needs to learn before graduation is also what he needs to remember afterward; the author has aimed to give such information and not much else. As far as possible, he states, the formulas have been tested by experiment or are based on the experience of manufacturers. A large part of the book contains information that has never before been brought together in such convenient form, and it is for this reason that a considerable use for the work will probably be found in the designing rooms of machine and engine shops. The author points out that while the underlying principles of machine design are permanent, the application of them is continually changing, and for this reason the book relates to those principles rather than to their applications in specific machines. (New York, Henry Holt & Co.)

There are two reasons for being gratified that Prof. Mansfield Merriman's "Elements of Sanitary Engineering" has reached a third edition;

in the first place, it is a good book, and in the second place the appearance of a new revised and enlarged edition shows that there is a healthy interest in the subject. Sanitarians are fully awake to the importance of many things that seem needless refinements to many people who consider themselves pretty well informed. In some branches of sanitary engineering there is a fair recognition on the part of the public of the importance of the subject, but a great deal remains to be done in the line of education of people to the effect of contaminated water, dirty streets and foul air in living and working rooms. A book like this deserves to have a very wide circulation; it is customary to teach young people in high schools and academies the principles of our form of government in order that they may assume with some efficiency their obligations as citizens, but for some reason it has never seemed necessary to teach them their obligations to each other in matters of public health, which is equally important. This journal is optimistic enough to believe in the eventual education of the public in matters of sanitation to such an extent that such a continuously filthy condition of streets as New York has presented this winter will not be tolerated. Just how much sickness and how many deaths have been due to this filth it is impossible to say, of course; but the reckoning must be a large one. Prof. Merriman's book explains the importance of sanitary science, the contamination and purification of water, the methods of distributing water to consumers, sewerage systems and sewage disposal, the collection and final disposal of refuse and garbage, and other subjects which everybody who takes an interest in public affairs ought to understand. (New York, John Wiley & Sons, $2.)

The rapid extension of the use of electrical apparatus in all kinds of engineering work finds expression in numerous inquiries received from civil engineers, whose work has not kept them in touch with electrical progress, for some book in which the present status of the subject is explained from the viewpoint of a reader who is not interested in the detailed design of apparatus so much as in what it is reasonable to expect from it when employed within the field for which it is adapted. Most electrical books hardly answer this requirement, for they are prepared, intentionally or otherwise, in such a way as to appeal mainly to readers who wish to learn the principles of electrical designing. This is not an adverse criticism of such books, but simply an explanation of the reason that so many books recommended by electrical engineers to civil and mechanical engineers are unsatisfactory for the purpose of the latter. This objection does not hold true of "Electrical Engineering in Theory and Practice," by Prof. G. D. Aspinwall Parr, head of the electrical department of Leeds University. It begins with an account of the fundamental phenomena of magnetism, static electricity and electrical currents. Electrical resistance is then taken up in considerable detail, and this chapter also explains the types of insulators in general use. Electro-magnetism and the principles of electro-magnets are considered in the next chapter, which is followed by one on electrostatic and electro-magnetic induction. The three succeeding chapters, on electrical and magnetic instruments, incandescent lamps and arc lights, describe the principles and uses of the various types of apparatus employed to-day. The last chapter is on thermo-couples, primary batteries and storage batteries. The theory of the generation, transformation and distribution of continuous and alternating currents, together with electrical machinery and other appliances most commonly used in electrical engineering, will form the subject of a later work. The present volume, however, covers the field which most needs such a book. Any one who wishes to obtain a good idea of the general principles of electrical power and lighting apparatus used to-day will find it a good book to study as an introduction to Dr. Louis Bell's well-known works on power transmission and electric lighting, and Mr. Adams' work on hydro-electric plants. The four books by these three authors give a very complete and reliable survey of the electrical field for technically educated readers who have no wish to go into the details which are the special province of the electrical engineers. (New York, The Macmillan Co., $3.25.)

Mr. E. R. Markham's "American Steel Worker" has been so successful that a second edition has recently been brought out, which is not surprising in view of the fact that the book relates mainly to the most neglected branch of machine-shop work, the preparation of cutting tools. It is pretty generally recognized that while a great deal of attention is given to the selection of machine tools and even to the choice of tool steel, the fabrication of that steel into cutting tools which will be most economical is left to men whose knowledge is based mainly on the rule-of-thumb teaching received from their predecessors. While many shop managers recognize that tool making ought to be improved in their works, they are too busy to give the matter personal attention and do not know where to turn for competent advice. In this book such information is given in much detail. It is a statement of the conclusions drawn by the author from 25 years of machine-shop experience. In it he points out at the beginning how the usual system of leaving the forging and hardening of cutting tools entirely to the class of men generally employed practically places the efficiency of the whole shop in the hands of the tool-makers, who are not able to carry such responsibility in most cases. The grades of steel suitable for tools are described in detail, and it is pointed out that there is considerable difference in brands of the same nominal grade, so that the methods of making tools from one of them cannot be followed exactly with some of the others. The description of the methods of heating the steel and the apparatus employed for the purpose occupies many pages, and ranges from the methods employed in the amateur's shop to the large cyanide of potassium furnaces employed where very fine work is turned out. The effect of different temperatures on tool steel is explained and the purpose and results of annealing are pointed out in some detail. Hardening is the next subject taken up, and afterward the method of drawing temper after hardening. Up to this point the text has referred to general principles rather special work, but directions for hardening a great variety of objects are given in the following section of the book. The subject of case hardening receives considerable attention, and is interesting as an explanation of the methods by which manufacturers of bicycles, sewing machines and other machinery have been enabled to substitute machine steel for tool steel for many parts, without any sacrifice of strength or resistance to wear. There is a chapter on tempering springs and a long one on the methods to follow and avoid in making tools of machine steel. So-called special and self-hardening steels are described and there are hints for the selection of the grade best suited to different kinds of tools. The causes of a good many troubles are explained and there are full directions for welding. Other subjects are discussed, but enough has been stated to show the scope of the book, which is well illustrated. (New York, Derry-Collard Co., $2.50.)

It has been pretty well acknowledged among engineers interested in pumping machinery and acquainted with French and German books on the subject as well as those in English, that the most comprehensive treatise was that written a good many years ago by Hartmann and Knoke. The rapid and important improvement in some kinds of pumps during late years has rendered a considerable portion of the work rather out of date, and the publishers have accordingly brought out a new edition revised by Prof. H. Berg, of the Stuttgart Polytechnic Institute. In the case of some of the chapters the revision has been a complete rewriting, and in other chapters considerable new information has been added. While these changes have been largely made to bring the descriptions of pumps into agreement with the types now manufactured, the theoretical portions of the text have been revised in places, particularly those relating to the phenomena of flow through satisfactory pumps and the principles of valve design. The first part of the book contains descriptions of wheels, screws and other devices of a crude nature for raising water to small heights. The theory of piston and plunger pumps is then examined in great detail, beginning with the conditions that occur when there is neither a suction chamber nor an air chamber, and proceeding step by step to a complete discussion of the conditions to be satisfied in regular service and the details of design to answer these requirements. The illustrations are drawn from pumps built by numerous German makers, who seem to have been remarkably generous in furnishing whatever drawings Prof. Berg required to make his book complete. In addition to these sketches of details, a large number of completed pumps of various types are described, and there are a number of excellently drawn plates of large pumping engines for mine and water-works service. It might be added as a matter of interest that the discussion of mechanically operated valves in the water end of pumping engines is decidedly unfavorable to them except where sewage must be handled. The portion of the book devoted to fan, rotary and screw pumps is naturally small, but it gives a fair idea of their general features and purposes; it might be well in the next edition to include a description of the Quimby screw pump, which is far superior to any of those illustrated. The explanation of the centrifugal pump will be found a fairly complete one, although it does not go into details to the same extent as Mr. Neumann's book noticed in this journal a few weeks ago. The description of centrifugal pumping plants includes notes and illustrations of some of the novel installations recently made in Continental mines and an interesting series of installations for the water-works of Milan. The remainder of the book is devoted to miscellaneous apparatus, such as syphons, air lifts, compressed air pumps, pulsometers, ejectors and injectors. The volume is one which should be in the library of every technical college whose students are taught to read German, as it is undoubtedly the most comprehensive work on this important subject. (Berlin, Julius Springer.)

All engineers who have looked into the subject of producer gas to any extent know that an important part in the development of plant for making it has been played by Mr. J. Emerson Dowson. Accordingly the announcement that he has brought out a book entitled "Producer Gas" is sufficient to ensure a wide sale for it, for such gas is to-day the most interesting feature of power plant engineering. Upon the degree of success with which it can be manufactured in apparatus entrusted to the same class of men who are employed in steam power plants depends the extent to which the gas engine will be introduced commercially. This book is written from the standpoint of a pioneer maker of producers who has had much success in introducing them. Naturally it contains a good deal about what he has done, but the reader is warned of this by the following statement in the preface: "I am afraid that in the course of what I have written I may have given undue prominence to what I have done myself; but, frankly, I have endeavored to avoid doing so, and I would ask that allowance be made for the fact that for many years my mind has been soaked with the subject and that to a considerable extent I have been obliged to seek results from trials and experiments I made myself." It should also be stated that Mr. Dowson gives credit for much of the book to his assistant, Mr. A. T. Larter, whose name appears on the title page as one of the authors. The first three chapters are devoted to a consideration of the formation of producer gas from a strictly theoretical point of view. This is done in order to make clear the rather complicated conditions under which the best gas can be made, since the best practical results can hardly be obtained unless the reasons for them are known. The indications of theory are compared with the results obtained in practice, and a number of minor topics connected with the main subject are discussed. The two chapters immediately following are devoted to heating and furnace uses of producer gas, and then follows a general chapter on engine work with producer gas. Two chapters are devoted to suction plants, and there is one on the use of bituminous fuels in producers making gas for engine use. While Mr Dowson is hopeful that bituminous coal can be successfully used in producers connected with engine plants, he states that under British conditions it is not at present advisable to employ such fuel in plants of less than 200 h.-p.; moreover, he looks upon present methods of using bituminous coal as tentative and not so satisfactory as the methods of using anthracite and coke. Two interesting chapters are devoted to a discussion of stand-by losses and a comparison of gas and steam power. It is interesting to observe that Mr. Dowson does not believe the gas engine will supplant the steam engine, but expects that each type of prime mover will eventually be found more suitable for certain classes of work than the other; what those special applications may be, he leaves for the future to show, as he believes the present status of producer gas plants is so indefinite that any opinions concerning what will happen are mere dreams. The remainder of the book is given up to a discussion of the properties of fuels and gases, and practical notes on working producers. There are several appendices giving tests of suction engine plants and various physical and technical data. The book is by all odds the most comprehensive one on the subject in English, and is particularly valuable as expressing the results of thirty years' study and practical experience with producers. (New York, Longmans, Green & Co., $3.)

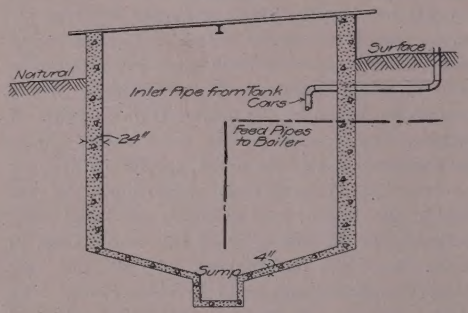
The Siphon of Sosa near Monzon in the province of Huesca, Spain, is formed of armored concrete, has a total length of 3,340 ft., and will discharge 7,700 gal. per second from the Canal of Aragon and Catalonia for the irrigation of about 262,000 acres in the valleys of the rivers Sosa and Rivabono. The siphon is composed of two tubes laid side by side on the surface of the ground. These tubes bear an internal pressure due to a head of 91.85 ft. According to Mr. E. Amontillado, from whose article in "La Nature" these notes have been taken, the method of conveying the water by means of a siphon instead of an aqueduct was selected as the cheaper system, after a competition in which the present plan, the design of Don José E. Ribera, who erected the MariaChristina bridge at Saint Sebastian, obtained the prize.

Letters to the Editor.

Leakage Through the Floor of the Soo Locks.

Sir: There was a statement in your editorial note on the Gatun dam and lock site printed on Jan. 26 which was in error. The statement is that "the locks at Sault Ste. Marie, resting on soft rock . . . leak so much that the timber bottom planking is not easily kept in place." The foundation rock there is Potsdam sandstone, the strata varying from hard to soft. There is no hesitation in founding upon the harder strata, and, so far as I recall, no trouble has ever been experienced from inadequacy of foundations. What repairs have been made in the floor have been over the filling culverts only, where the floor is subjected to the direct upward pressure due to the head and the holding-down bolts have to withstand the vibration caused by the rapidly flowing water. The necessity of these repairs has not arisen from the character of the rock foundation. As the rock is not homogeneous, there is leakage along seams which must be considered in design and construction, but I do not recall that this has ever led to any trouble not anticipated. X.

[This note is from an engineer who has had an opportunity to become acquainted with the facts of the leakage mentioned, and may be accepted as strictly correct.—Editor.]



A Concrete Oil Reservoir.

Concrete Oil Tanks.

Sir: In answer to H. V. Cloll's question in your issue of Feb. 9th I can say that I built a concrete-lined storage reservoir for fuel oil, to serve the boilers of the pumping station of the International Water Co., at El Paso, Texas. After painting it with a good coat of coal tar, it gave satisfaction.

Yours truly,

H. T. Poe, Jr.

Greenville, S. C., Feb. 15.

Weakness in Reinforced Concrete Structures.

Sir: Referring to your editorial comment in the issue of Feb. 9, and to recent correspondence in your paper on the subject of failure of reinforced concrete structures, I would like to make a suggestion as to a probable cause of weakness in many cases, if not directly a cause for failure.

In the placing of concrete in girders and floor systems it is quite a common procedure to start near the hoisting tower and work toward the opposite side of the building. In which case concrete placed in the early part of the day and having received an initial set, is subjected to the continual passage of wheelbarrows heavily loaded and roughly handled over runways of single planking unevenly laid, and with no regard for deflections and vibrations which will be produced in the freshly laid floor. These deflections and vibrations are often quite considerable, as the rigidity is only that offered by the supporting forms. I have seen a panel of floor after having been subjected to the vibrations and shocks due to one thousand loaded wheelbarrows and two thousand men passing over it before it was ten hours old, with cracks extending at right angles to the reinforcements so large that they were noticeable in the light of an arc lamp. And on the following day when the concrete had a good firm set, these same cracks were fully as noticeable.

Another feature which it seems to me should receive more attention is providing an adequate sway-bracing for the centering. In discharging the contents from a wheelbarrow (some 200 lb.) into a girder or narrow column there are often produced jars and lateral movements which may affect very materially freshly placed concrete in adjoining panels. The effect of the wind on exposed structures under erection should be carefully provided for as well. I have no doubt that some of the failures which have been charged to the removing of centering while concrete was too green, might be traced to some cause like those suggested which interfered with the proper setting during its early stage.

An Interested Reader.

New York, Feb. 11, 1907.

Pavement Foundations.

Sir: I note in the Record of Feb. 9, an article on "Improved Pavement Foundations," describing the method used at Easton, Pa., for reconstructing the concrete foundations over back-filling, when repaving the streets over trenches. The specifications require that after properly back-filling the trench, "the old concrete shall be removed at least 1 ft. on each side of the trench, and expanded metal placed over the entire opening." This is to form a reinforcement for the 6-in. concrete foundation for the street paving. Experience seems to indicate that a 6-in. concrete foundation properly placed and of a suitable quality (a 1:3:5 mixture would seem to be good) will support the pavement under any ordinary load and do this even where the back-filling is not all that may be desired. The placing of a reinforcement will be an unnecessary refinement, tending to increase the cost of repaving with no resulting advantage. There is, however, a very positive objection to this method, and that is the increasing cost and difficulty that will be encountered in opening up the street in the future. Even with a wide street, after allowing for a double line of car tracks, there is not so very much room left for the various public utilities that are necessarily placed underground. And if the streets are interlaced with a network of reinforced strips of foundation there will be increasing difficulty encountered by those who may have to open the street. It is not an easy job to open a trench through a properly constructed foundation and it will be considerably more difficult if an expanded metal reinforcement will have to be taken care of at the same time. I admit that opening paved streets should not be encouraged, but all who have had to deal with work of this class know that it is absolutely necessary to do so. Certain structures must be placed underground. That is the universal experience, and the number of these structures is increasing; it is only a matter of a little time when the main streets of Easton will be pretty well filled with various pipes and conduits beneath the pavement. If this practice of reinforcing the repair work is continued it is quite likely that instead of being regarded as an improvement, it will, in the not very distant future, be looked on as a very decided obstacle to placing some structures underground.

Very truly yours.

Edwin M. Evans.

Philadelphia, Feb. 18.

The Alamogorda & Sacramento Mt. Ry., in New Mexico, at present a branch of the El Paso & Southwestern system, has a maximum curvature of 30 deg., and a maximum gradient of 5.2 per cent., compensated 0.03 per cent. per degree of curvature.